U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Ocean Service

Data Acquisition & Processing Report

Type of Survey:	Navigable Area
Project Number:	OPR-E350-TJ-19
Time Frame:	July - December 2019

LOCALITY

State(s):	Virginia
General Locality:	Southern Chesapeake Bay

2019

CHIEF OF PARTY
CDR Briana Welton Hillstrom, NOAA

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Table of Contents

List of Figures

Data Acquisition and Processing Report

NOAA Ship Thomas Jefferson (S222)
Chief of Party: CDR Briana Welton Hillstrom, NOAA
Year: 2019
Version: 1.0
Publish Date: 2020-04-24

A. System Equipment and Software

A.1 Survey Vessels

A.1.1 Hydrographic Survey Launch 2903 (HSL 2903)

Vessel Name	Hydrographic Survey Launch 2903 (HSL 2903)	
Hull Number	2903	
Description	HSL 2903 is an aluminum hulled hydrographic survey launch built in 2017 by Willard Marine, Inc. HSL 2903 is equipped to collect bathymetric data, side scan imagery, and water column profiles.	
Dimensions	*LOA*	8.5m
	Beam	3m
	Max Draft	1.2m
Most Recent Full Static Survey	*Date*	2017-05-01
	Performed By	Kevin Jordan, National Ocean Service - National Geodetic Survey (NGS) - Field Operations Branch
Most Recent Partial Offset Verification	*Date*	2019-06-03
	Method	Physical confirmation of measurements.

Figure 1: 2903 and 2904 returning to S222

Figure 2: 2903 heading out for survey operations.

Figure 3: 2903 from starboard view.

A.1.2 Hydrographic Survey Launch 2904 (HSL 2904)

<table>
<tr><td><i>Vessel Name</i></td><td colspan="2">Hydrographic Survey Launch 2904 (HSL 2904)</td></tr>
<tr><td><i>Hull Number</i></td><td colspan="2">2904</td></tr>
<tr><td><i>Description</i></td><td colspan="2">HSL 2904 is an aluminum hulled hydrographic survey launch built in 2017 by Willard Marine, Inc. HSL 2904 is equipped to collect bathymetric data, side scan imagery, and water column profiles.</td></tr>
<tr><td rowspan="3"><i>Dimensions</i></td><td><i>LOA</i></td><td>8.5m</td></tr>
<tr><td><i>Beam</i></td><td>3m</td></tr>
<tr><td><i>Max Draft</i></td><td>1.2m</td></tr>
<tr><td rowspan="2"><i>Most Recent Full Static Survey</i></td><td><i>Date</i></td><td>2017-04-30</td></tr>
<tr><td><i>Performed By</i></td><td>Kevin Jordan, National Ocean Service - National Geodetic Survey (NGS) - Field Operations Branch</td></tr>
</table>

Most Recent Partial Offset Verification	*Date*	2019-06-03
	Method	Physical confirmation of measurements.

Figure 4: 2904 from port view.

A.2 Echo Sounding Equipment

A.2.1 Multibeam Echosounders

A.2.1.1 Kongsberg EM2040

The Kongsberg EM2040 MBES is a high resolution shallow water MBES. The system is capable of operating at 200, 300, or 400 kHz frequencies, can provide across-track swath width up to 5.5 times water depth, provides single or multi-sector modes of operations, and can be used in depths up to 600 meters.

The EM2040 is operated at the 300 kHz frequency for normal shallow water operations.

For hydrographic survey collection, the EM2040 is set to a max angle of 65 degrees with angular coverage set to Auto. The beam spacing is set to high definition equal distant to obtain max swath width when operating in any depth. Dual swath mode is set to Dynamic. Dynamic mode is selected because it allows the along side angle between the two transmit fans to be determined based on the vessel speed, ping rate, and depth in order to provide a uniform along ship sampling of the sea floor. The frequency of the EM2040 is typically set to 300 kHz for normal survey operations, and will shift to 400 kHz for shallow water data collection. Pulse type set to auto with FM disabled.

Components of the EM2040 include a sonar head, a processing unit, and a hydrographic workstation. Motion sensor and positioning data from the POSMV system, with sound speed profile data being input to the EM 2040 via separate sound speed profiling equipment. All echo sounder electronics are contained in the sonar head which is interfaced to the processing unit via GBit Ethernet. The processing unit also supplies 48 VDC power via the same cable. Operator control, data quality inspection, and data storage is handled by the hydrographic workstation running SIS software.

The Sonar Acceptance Reports for the EM2040s on both Hydrographic Survey Launches can be found in the appendices.

<table>
<tr><td><i>Manufacturer</i></td><td colspan="2">Kongsberg</td></tr>
<tr><td><i>Model</i></td><td colspan="2">EM2040</td></tr>
<tr><td rowspan="2"><i>Inventory</i></td><td><i>2903</i></td><td>
<table>
<tr><td><i>Component</i></td><td>Processing Unit</td><td>Work Station</td><td>Transducer</td><td>Receiver</td></tr>
<tr><td><i>Model Number</i></td><td>EM2040</td><td>EM2040</td><td>EM2040</td><td>EM2040</td></tr>
<tr><td><i>Serial Number</i></td><td>40143</td><td>CZC746864F</td><td>281</td><td>363</td></tr>
<tr><td><i>Frequency</i></td><td>200-400 kHz</td><td>200-400 kHz</td><td>200-400 kHz</td><td>200-400 kHz</td></tr>
<tr><td><i>Calibration</i></td><td>2019-09-26</td><td>2019-09-26</td><td>2019-09-26</td><td>2019-09-26</td></tr>
<tr><td><i>Accuracy Check</i></td><td>2019-10-10</td><td>2019-10-10</td><td>2019-10-10</td><td>2019-10-10</td></tr>
</table>
</td></tr>
<tr><td><i>2904</i></td><td>
<table>
<tr><td><i>Component</i></td><td>Processing Unit</td><td>Work Station</td><td>Transducer</td><td>Receiver</td></tr>
<tr><td><i>Model Number</i></td><td>EM2040</td><td>EM2040</td><td>EM2040</td><td>EM2040</td></tr>
<tr><td><i>Serial Number</i></td><td>40139</td><td>CZC7468666</td><td>282</td><td>393</td></tr>
<tr><td><i>Frequency</i></td><td>200-400 kHz</td><td>200-400 kHz</td><td>200-400 kHz</td><td>200-400 kHz</td></tr>
<tr><td><i>Calibration</i></td><td>2019-07-15</td><td>2019-07-15</td><td>2019-07-15</td><td>2019-07-15</td></tr>
<tr><td><i>Accuracy Check</i></td><td>2019-07-15</td><td>2019-07-15</td><td>2019-07-15</td><td>2019-07-15</td></tr>
</table>
</td></tr>
</table>

Figure 5: Kongsberg EM2040 mounting configuration on 2903 and 2904

A.2.2 Single Beam Echosounders

A.2.2.1 Teledyne Odom Echotrac CV200

The Teledyne Odom Echotrac CV200 single beam echo sounder (SBES) has a low band frequency of 3.5kHz-50kHz and a high band frequency of 100kHz-1MHz allowing for survey to depths of up to 4000 meters. The hydrographers operated the Echotrac CV200 at 128kHz with the entire system interfaced and logged through Hypack 2018 acquisition software. The single beam data was logged as a .raw and .bin file through Hypack 2018, with only the .raw files processed in Caris Hips and Sips 10.4 processing software.

The system is comprised of a topside unit and a hull-mounted transducer.

For the Odom Echotrac installation, calibration, and verification refer to the appendices.

<table>
<tr><td><i>Manufacturer</i></td><td colspan="4">Teledyne Odom</td></tr>
<tr><td><i>Model</i></td><td colspan="4">Echotrac CV200</td></tr>
<tr><td rowspan="6"><i>Inventory</i></td><td rowspan="6"><i>2903</i></td><td><i>Component</i></td><td>Processing Unit</td><td>Transducer</td></tr>
<tr><td><i>Model Number</i></td><td>CV200</td><td>CV200</td></tr>
<tr><td><i>Serial Number</i></td><td>002917</td><td>UNKNOWN</td></tr>
<tr><td><i>Frequency</i></td><td>3.5kHz-1MHz</td><td>3.5kHz-1MHz</td></tr>
<tr><td><i>Calibration</i></td><td>2019-06-03</td><td>2019-06-03</td></tr>
<tr><td><i>Accuracy Check</i></td><td>2019-06-05</td><td>2019-06-05</td></tr>
</table>

Figure 6: Installation of transducer for Odom Echotrac CV200 on the hull of 2903.

A.2.3 Side Scan Sonars

A.2.3.1 Klein Marine Systems, Inc. 5000 MKII-B

The Klein System 5000 MKII-B is a high performance, 5 beam dynamically focused, economical system designed specifically for port and harbor security applications and is also ideally suited for small object detection in open boat operations. Performance of the Klein System 5000 MKII-B is comparable to the specifications and performance of the Klein System 5000 technology. The towfish is fitted to the HSL's in a hull-mounted configuration. The MKII-B is restricted to the depth of the draft of the HSL.

The Klien 5000 MKII-B has a set range scale of 50 meters, 75 meters, 100 meters, and 150 meters.

<table>
<tr><td><i>Manufacturer</i></td><td colspan="2">Klein Marine Systems, Inc.</td></tr>
<tr><td><i>Model</i></td><td colspan="2">5000 MKII-B</td></tr>
<tr><td><i>Inventory</i></td><td><i>2903</i></td><td>
<table>
<tr><td><i>Component</i></td><td>Processing Unit</td><td>Towfish</td></tr>
<tr><td><i>Model Number</i></td><td>5000 MKII-B</td><td>5000 MKII-B</td></tr>
<tr><td><i>Serial Number</i></td><td>009</td><td>319</td></tr>
<tr><td><i>Frequency</i></td><td>455kHz</td><td>455kHz</td></tr>
<tr><td><i>Calibration</i></td><td>2019-07-24</td><td>2019-07-24</td></tr>
<tr><td><i>Accuracy Check</i></td><td>2019-07-24</td><td>2019-07-24</td></tr>
</table>
</td></tr>
</table>

Figure 7: Klein 5000 MKII-B installed on the launch.

A.2.3.2 EdgeTech 4200

The EdgeTech 4200 system is comprised of a topside system and a stainless steel towfish. The towfish is a dual frequency 300/600 kHz capable of simultaneous acquisition in both frequencies. The towfish is fitted to the HSL in a hull-mounted configuration. The 4200 is restricted to the depth of the draft of the HSL.

The EdgeTech 4200 uses Multi-Pulse (MP) technology to enable survey speeds up to 10 knots while maintaining 100% bottom coverage. When operated in simultaneous dual frequency acquisition mode, speed must be reduced since the frequencies alternate between 300 and 600 kHz.

Manufacturer	EdgeTech			
Model	4200			
Inventory	*2903*	*Component*	TPU	Towfish
		Model Number	4200	4200
		Serial Number	50423	40423
		Frequency	300kHz-600kHz	300kHz-600kHz
		Calibration	2019-07-02	2019-07-02
		Accuracy Check	2019-07-02	2019-07-02
	2904	*Component*	TPU	Towfish
		Model Number	4200	4200
		Serial Number	50426	50508
		Frequency	300kHz-600kHz	300kHz-600kHz
		Calibration	2019-07-03	2019-07-03
		Accuracy Check	2019-07-03	2019-07-03

A.2.4 Phase Measuring Bathymetric Sonars

No phase measuring bathymetric sonars were utilized for data acquisition.

A.2.5 Other Echosounders

No additional echosounders were utilized for data acquisition.

A.3 Manual Sounding Equipment

A.3.1 Diver Depth Gauges

No diver depth gauges were utilized for data acquisition.

A.3.2 Lead Lines

No lead lines were utilized for data acquisition.

A.3.3 Sounding Poles

No sounding poles were utilized for data acquisition.

A.3.4 Other Manual Sounding Equipment

No additional manual sounding equipment was utilized for data acquisition.

A.4 Horizontal and Vertical Control Equipment

A.4.1 Base Station Equipment

No base station equipment was utilized for data acquisition.

A.4.2 Rover Equipment

No rover equipment was utilized for data acquisition.

A.4.3 Water Level Gauges

No water level gauges were utilized for data acquisition.

A.4.4 Levels

No levels were utilized for data acquisition.

A.4.5 Other Horizontal and Vertical Control Equipment

No other equipment were utilized for data acquisition.

A.5 Positioning and Attitude Equipment

A.5.1 Positioning and Attitude Systems

A.5.1.1 Applanix Corporation POS MV 320 Version 5

The Applanix POS MV 320 Version 5 (Position and Orientation System for Marine Vessels, hereafter ‘POS MV v5’) is a GNSS Inertial Navigation System that provides high frequency and highly accurate vessel trajectory (both navigation/position and attitude/orientation) data. The system incorporates data from an Inertial Motion Unit (IMU) and dual multi-constellation GNSS receivers. Advanced proprietary Kalman

Filtering techniques are used to provide a blended navigation and trajectory solution in real-time that is both highly accurate and reliable. The POS MV v5 also computes vessel heave (both instantaneous and 'delayed' heave values). The POS MV v5 system is integrated with all platform acquisition systems. Data from the POS MV v5 is applied to echosounder data in real-time and logged for post-processing/archiving.

The POS/ MV generates attitude data in three axes (roll, pitch, and heading) to an accuracy of 0.02° or better. Real-time heave measurements supplied by the POS/MV maintain an accuracy of 5% of the measured vertical displacement or 05 cm (whichever is greater) for vertical motions less than 20 seconds in period. The standard practice on THOMAS JEFFERSON is to configure the Heave Bandwidth filter with a damping coefficient of 0.707. The standard practice is to apply a high pass filter that is determined by the longest swell period encountered on the survey grounds. The POS MV v5 is also calculates a 'delayed heave' (Applanix labels this 'TrueHeave') value. The Applanix delayed heave algorithm uses a delayed filtering technique to eliminate many of the artifacts present in real time heave data. Applanix delayed heave measurements maintain an accuracy of 2% of the measured vertical displacement or 2 cm (whichever is greater) for vertical motions less than 20 seconds in period. Delayed heave measurements are logged and applied to MBES data in post processing.

A graphical user interface provides visual representations and summary statistics of data quality in real-time. Performance parameters are monitored by acquisition hydrographers in real-time and checked against HSSD requirements.

Position and trajectory data from the POS MV v5 system is applied in both real-time and post-processed applications. Navigation and attitude data are applied to all echosounder data in real-time. Raw data from the POS MV v5 can also be post-processed after acquisition to achieve trajectory solutions that are more accurate than those achieved in real-time by using forward/backward processing methods. Post-processing is conducted using the Applanix POSPac MMS software suite. Post-processing methodology is described elsewhere in this document.

Position and Attitude data are recorded daily in 10 minute file increments to a computer at 100Hz through an Ethernet connection, on a dedicated POS MV acquisition computer with no other applications running.

Manufacturer	Applanix Corporation			
Model	POS MV 320 Version 5			
Inventory	*2903*	*Component*	IMU	PCS
		Model Number	LN200 (IMU2)	V5
		Serial Number	131	3245
		Calibration	2019-07-15	2019-07-15
	2904	*Component*	IMU	PCS
		Model Number	LN200 (IMU2)	V5
		Serial Number	293	8959
		Calibration	2019-09-26	2019-09-26

A.5.2 DGPS

DGPS equipment was not utilized for data acquisition.

A.5.3 GPS

GPS equipment was not utilized for data acquisition.

A.5.4 Laser Rangefinders

A.5.4.1 Velodyn VLP-16

The VLP-16 has a range of 100 m. Velodyne's LiDAR Puck supports 16 channels, ~300,000 points/second, 360° horizontal field of view and a 30° vertical field of view, with ±15° up and down.

Manufacturer	Velodyn		
Model	VLP-16		
Inventory	*2903*	*Component*	Puck
		Model Number	VLP-16
		Serial Number	AF29314363
		Calibration	2019-06-10

A.5.5 Other Positioning and Attitude Equipment

No additional positioning and attitude equipment was utilized for data acquisition.

A.6 Sound Speed Equipment

A.6.1 Moving Vessel Profilers

No moving vessel profilers were utilized for data acquisition.

A.6.2 CTD Profilers

A.6.2.1 Sea-bird Electronics SBE 19plus

The Sea-Bird Electronics SBE 19plus SeaCAT profiler measures conductivity, temperature, and depth (CTD) in marine and/or freshwater environments. The SBE 19plus is rated for use at depths of up to 600 meters and is capable of sampling at a rate of 4 measurements per second. CTD values are used to calculate the speed of sound through the water column.

Sea-Bird Electronics SBE 19plus Conductivity, Temperature, and Depth (CTD) Profilers are used on 2903 and 2904 to collect vertical sound speed profiles. The speed of sound is calculated from temperature, salinity, and pressure measurements. Temperature is measured directly. Salinity is calculated from measured electrical conductivity. Depth is calculated via strain gauge pressure sensor. The system is configured for a sampling rate of 0.5 seconds. CTD equipment is deployed manually aboard TJ launches. The CTD is deployed over the side of the vessel. The CTD is first soaked for 2 minutes before letting the device free fall to the bottom and then recovered at a rate roughly equal to 1 meter per second.

Manufacturer	Sea-bird Electronics	
Model	SBE 19plus	
Inventory	*Component*	CTD
	Model Number	19plus
	Serial Number	19P33589-4487
	Calibration	2019-02-24
	Component	CTD
	Model Number	19plus
	Serial Number	19P36399-4630
	Calibration	2018-05-09

A.6.3 Sound Speed Sensors

A.6.3.1 Teledyne Reson Reson SV-71

The Reson SVP-70 and SVP-71 are direct-read sound speed measurement devices. The SVP devices obtain sound speed measurements by directly measuring the travel time of sound pulses along a set 125 mm transmission path. The SVP systems are capable of reading sound speeds from 1350 to 1800 m/s with a resolution of 0.01 m/s (±0.15m/s) at a sampling rate of 20 Hz.

Reson SV-71 sensors collect the speed of sound at the face of the Kongsberg EM2040 transducers on 2903 and 2904. The sensors are bolted to the mounting sleds near the face of the transducer on each launch. The speed of sound is measured directly using a direct path echosounding sensor. The SV-71 is integrated with the Kongsberg EM2040.

<table>
<tr><td>Manufacturer</td><td colspan="3">Teledyne Reson</td></tr>
<tr><td>Model</td><td colspan="3">Reson SV-71</td></tr>
<tr><td rowspan="8">Inventory</td><td rowspan="4">2903</td><td>Component</td><td>Probe</td></tr>
<tr><td>Model Number</td><td>SVP-71</td></tr>
<tr><td>Serial Number</td><td>1213045</td></tr>
<tr><td>Calibration</td><td>2018-08-30</td></tr>
<tr><td rowspan="4">2904</td><td>Component</td><td>Probe</td></tr>
<tr><td>Model Number</td><td>SVP-71</td></tr>
<tr><td>Serial Number</td><td>1213050</td></tr>
<tr><td>Calibration</td><td>2018-09-02</td></tr>
</table>

A.6.4 TSG Sensors

No surface sound speed sensors were utilized for data acquisition.

A.6.5 Other Sound Speed Equipment

No surface sound speed sensors were utilized for data acquisition.

A.7 Computer Software

Manufacturer	*Software Name*	*Version*	*Use*
Caris	HIPS	10.4	Processing
Caris	BASE Editor	5.3	Processing
NOAA	Pydro (ie: Charlene, QC tools 3, XmlDR, SHAM, transmission letter, Sound Speed Manager)	19.4	Processing
HYPACK - A Xylem Brand	HYPACK	2018	Acquisition
Applanix Corporation	POSPac MMS	8.4	Processing
Applanix Corporation	POSView	10.0	Acquisition
ESRI, Inc.	ArcGIS	10.6.1	Processing
QPS, Inc	FMGT	7.9.2	Processing
Kongsberg	Seafloor Information System (SIS)	4.3.2	Acquisition
Edgetech	Discover 4200-MP	37.0.1.111	Acquisition
Klein Marine Systems, Inc	SonarPro	14.1	Acquisition
Novatel Waypoint	GrafNav	8.70	Processing
iXblue	APPS	2.0.3	Processing
QPS, Inc	FMGT	7.8.10	Processing
QPS, Inc	Qimera	1.7.6	Acquisition
QPS, Inc	Qinsy	8.18.4	Acquisition
Teledyne Odom	eChart	1.4.0	Aquisition
NOAA	Pydro Explorer	19.4(r10747)	Post processing data integrity and quality management
NOAA	Sounds Speed Manager	2019.2.5	Aquisition and processing
NOAA	QC Tools	3.1.6	Post processing data integrity and quality management
NOAA	Flier Finder	8	Post processing data integrity and quality management
NOAA	Grid QA	5	Post processing data integrity and quality management
NOAA	Holiday Finder	4	Post processing data integrity and quality management
NOAA	Gridded Surface Comparison	19.4(r10747)	Post processing data integrity and quality management

A.8 Bottom Sampling Equipment

A.8.1 Bottom Samplers

A.8.1.1 Ponar Wildco Model #1728

The Ponar Wildco is a winch-deployed bottom sampler used aboard S222, 2903, and 2904. The sampler is a Ponar type grab sampler of a design commonly used to sample a wide variety of sediment types. The sampler design uses self-tripping center hinged jaws and a spring loaded trigger pin that releases when the sampler makes impact with the bottom. The sampler’s jaws are closed by the scissor action of the lever arms when the sampler is retrieved. The sampling area is 6" x 6".

Figure 8: Ponar Wildco bottom sampler

A.8.1.2 Kahlisco Mud Snapper 214WA100 (AKA 'The Nibbler')

The Kahlisco Mud Snapper is a hand held bottom sampler used to take bottom samples from 2903 and 2904. The Mud Snapper is a foot-trip model clam shell style bottom sampler. This sampler is designed to collect unconsolidated sediments up to the size of small pebbles. The sampler is fabricated from sturdy bronze and stainless steel materials for trouble-free service in a marine environment. The unit consists of a long threaded post surrounded by a strong compression spring that presses against the jaws at one end and an adjustable screw cap at the upper end. By turning this threaded cap the spring-compression is adjusted, changing the strength at which the jaws close. A shackle is attached through a hole on the top of the post and a line attached. Due to the small size of this sampler, it may be deployed either by using a heavy-duty fishing pole or a handline.

Figure 9: Kahlisco Mud Snapper bottom sampler

B. System Alignment and Accuracy

B.1 Vessel Offsets and Layback

B.1.1 Vessel Offsets

All offsets for 2903 and 2904 are derived from full vessel surveys performed by personnel from the National Geodetic Survey (NGS). Offset values are known in the vessel reference frame, the IMU reference frame, and Kongsberg reference frame. Offset values for the Kongsberg MBES systems are entered into POS/MV, with the exception of the orthogonal offsets between the transducer and receiver. These values are entered into SIS and the HSL's Caris HVF. The offset between the primary GNSS antenna and the IMU is applied within the POS/MV. The reference point for the HSL's is the Kongsberg EM2040 transducer face. The POS/MV provides navigation and attitude data in the Kongsberg reference frame at the transducer face reference point. All other offsets are applied to data during the SVP or Merge processing steps in CARIS HIPS.

Offsets are applied to side scan sonar data during the Compute Towfish Navigation step.

All offsets, correctors, and values used in TPU calculation that are stored in the HVF file can be found in the Appendices to this report. HVF Reports are output from the Caris HVF Editor in a plain text document readable anywhere and include all of the requested values for the DAPR necessary to reproduce an HVF.

For a detailed look at the applied lever arms and mounting angles, refer to the appendices.

B.1.1.1 Vessel Offset Correctors

Vessel	2903			
Echosounder	Kongsberg EM2040			
Date	2019-11-12			
Offsets	*MRU to Transducer*		*Measurement*	*Uncertainty*
		x	0.205 meters	0.020 meters
		y	0.152 meters	0.020 meters
		z	0.536 meters	0.020 meters
		x2	-0.100 meters	0.020 meters
		y2	0.052 meters	0.020 meters
		z2	0.520 meters	0.020 meters
	Nav to Transducer	*x*	0.922 meters	0.020 meters
		y	0.896 meters	0.020 meters
		z	4.185 meters	0.020 meters
		x2	0.617 meters	0.020 meters
		y2	0.796 meters	0.020 meters
		z2	4.169 meters	0.020 meters
	Transducer Roll	*Roll*	-0.965 degrees	

Vessel	2903			
Echosounder	Kongsberg EM2040			
Date	2019-09-26			
Offsets			*Measurement*	*Uncertainty*
	MRU to Transducer	*x*	0.177 meters	0.020 meters
		y	0.141 meters	0.020 meters
		z	0.577 meters	0.020 meters
		x2	-0.128 meters	0.020 meters
		y2	0.041 meters	0.020 meters
		z2	0.561 meters	0.020 meters
	Nav to Transducer	*x*	0.922 meters	0.020 meters
		y	0.896 meters	0.020 meters
		z	4.185 meters	0.020 meters
		x2	0.617 meters	0.020 meters
		y2	0.796 meters	0.020 meters
		z2	4.169 meters	0.020 meters
	Transducer Roll	*Roll*	-0.021 degrees	

Vessel	2904			
Echosounder	Kongsberg EM2040			
Date	2019-07-08			
Offsets			*Measurement*	*Uncertainty*
	MRU to Transducer	*x*	0.165 meters	0.020 meters
		y	0.143 meters	0.020 meters
		z	0.579 meters	0.020 meters
		x2	-0.115 meters	0.020 meters
		y2	0.057 meters	0.020 meters
		z2	0.522 meters	0.020 meters
	Nav to Transducer	*x*	0.923 meters	0.020 meters
		y	0.889 meters	0.020 meters
		z	4.193 meters	0.020 meters
		x2	0.618 meters	0.020 meters
		y2	0.789 meters	0.020 meters
		z2	4.177 meters	0.020 meters
	Transducer Roll	*Roll*	-0.050 degrees	

Vessel	2904			
Echosounder	Kongsberg EM2040			
Date	2019-12-05			
Offsets			*Measurement*	*Uncertainty*
	MRU to Transducer	*x*	0.165 meters	0.020 meters
		y	0.144 meters	0.020 meters
		z	0.579 meters	0.020 meters
		x2	-0.140 meters	0.020 meters
		y2	0.044 meters	0.020 meters
		z2	0.563 meters	0.020 meters
	Nav to Transducer	*x*	0.923 meters	0.020 meters
		y	0.889 meters	0.020 meters
		z	4.193 meters	0.020 meters
		x2	0.618 meters	0.020 meters
		y2	0.789 meters	0.020 meters
		z2	4.177 meters	0.020 meters
	Transducer Roll	*Roll*	0.000 degrees	

Vessel	2904			
Echosounder	Kongsberg EM2040			
Date	2019-12-18			
Offsets			*Measurement*	*Uncertainty*
	MRU to Transducer	*x*	0.165 meters	0.020 meters
		y	0.144 meters	0.020 meters
		z	0.579 meters	0.020 meters
		x2	-0.140 meters	0.020 meters
		y2	0.044 meters	0.020 meters
		z2	0.563 meters	0.020 meters
	Nav to Transducer	*x*	0.923 meters	0.020 meters
		y	0.889 meters	0.020 meters
		z	4.193 meters	0.020 meters
		x2	0.618 meters	0.020 meters
		y2	0.789 meters	0.020 meters
		z2	4.177 meters	0.020 meters
	Transducer Roll	*Roll*	0.000 degrees	

B.1.2 Layback

Layback error is calculated by running a side scan certification test. This test consists of running parallel to a known feature at varying ranges from nadir to ensonify the target in the near-field (approximately 15% of range scale in use), mid-field (approximately 50 % of range scale in use), and far-field (approximately 85% of the range scale in use). The test requires that each side of the sonar ensonify the feature at each of these areas in the swath. Then the test is repeated in a direction that is orthogonal to the original set of lines such that the feature is ensonified a total of 12 times. A successful test will detect the feature in at least 10 of the 12 passes. For hull-mounted systems, the selected contact positions must be within 5m; for towed systems, the contact positions must be within 10m. Layback error is the amount of correction that must be applied to minimize the distance between contact positions.

B.1.2.1 Layback Correctors

Vessel	2903		
Echosounder	Edgetech 4200		
Frequency	600 kHz		
Date	2019-07-02		
Layback	*Towpoint*	*x*	0.564 meters
		y	0.654 meters
		z	0.310 meters
	Layback Error	0.000 meters	

Vessel	2903		
Echosounder	Klein 5000MKII-B		
Frequency	455 kHz		
Date	2019-07-24		
Layback	*Towpoint*	*x*	0.564 meters
		y	0.654 meters
		z	0.310 meters
	Layback Error	0.000 meters	

Vessel	2904		
Echosounder	Klein 5000MKII-B		
Frequency	455 kHz		
Date	2019-07-03		
Layback	*Towpoint*	*x*	0.574 meters
		y	0.659 meters
		z	0.306 meters
	Layback Error	0.000 meters	

B.2 Static and Dynamic Draft

B.2.1 Static Draft

The static draft is not applied to soundings for ERS surveys.

The waterline for HSL platforms is measured using physical measurements from the waterline of the vessel to physical known benchmarks.

All offsets, correctors, and values used in TPU calculation that are stored in the HVF file can be found in the included Appendix Folder, HVF Reports. These HVF Reports are output from the Caris HVF Editor in a plain text document readable anywhere, and include all of the requested values for the DAPR necessary to reproduce an HVF.

B.2.1.1 Static Draft Correctors

Vessel		2903	2904
Date		2019-07-16	2019-07-16
Loading		0.03 meters	0.03 meters
Static Draft	*Measurement*	-0.615 meters	-0.618 meters
	Uncertainty	0.03 meters	0.03 meters

B.2.2 Dynamic Draft

Dynamic draft for all platforms was measured using the Post Processed Kinematic GPS method outlined in section 1.4.2.1.2.1 of NOAA's FPM. To reduce the effect of any potential current, reciprocal lines were run at each RPM step in order to get an average speed over ground for each RPM. This average speed was used to estimate the vessel’s speed through the water. Dynamic draft and vessel offsets corrector values are stored in the Hydrographic Vessel Files (HVF).

In ERS surveys (those that use recorded GPS heights corrected via a VDatum SEP model to achieve tidal datum) the dynamic draft correction is not applied to the soundings.

All offsets, correctors, and values used in TPU calculation that are stored in the HVF can be found in the HVF Values section in the DAPR appendices. These HVF Reports are output from the Caris HVF Editor in a plain text document readable anywhere, and include all of the requested values for the DAPR necessary to reproduce an HVF.

B.2.2.1 Dynamic Draft Correctors

Vessel	2903		2904	
Date	2019-06-01		2019-07-07	
Dynamic Draft	*Speed (m/s)*	*Draft (m)*	*Speed (m/s)*	*Draft (m)*
	0.00	0.00	0.00	0.00
	0.50	-0.01	0.50	-0.17
	1.00	-0.00	1.00	-0.13
	1.50	0.01	1.50	0.00
	2.00	0.03	2.00	0.02
	2.50	0.05	2.50	0.04
	3.00	0.06	3.00	0.05
	3.50	0.07	3.50	0.06
	4.00	0.06	4.00	0.06
	4.50	0.04	4.50	0.04
	5.00	0.01	5.00	0.01
	5.50	-0.05	5.50	-0.23
	6.00	-0.13	6.50	-0.12
			7.00	-0.17
Uncertainty	*Vessel Speed (m/s)*	*Delta Draft (m)*	*Vessel Speed (m/s)*	*Delta Draft (m)*
	0.50	0.02	0.50	0.03

B.3 System Alignment

B.3.1 System Alignment Methods and Procedures

THOMAS JEFFERSON conducts MBES calibration tests during annual HSRR activities for each individual multibeam system on the ship and her launches.

The procedure used is outlined in Section 1.5.5.1 of the Field Procedures Manual dated April 2014. The method used to determine timing bias was running the same line at different speeds. Pitch and yaw bias was determined using a target on the seafloor. Finally, roll bias was determined using the standard flat bottom method. Offset values for all platforms were derived using Caris' patch testing tools during annual HSRR activities.

Patch test values for 2903 and 2904 are applied within POS MV software at acquisition with the exception of data collected on Julian day numbers 339-355 for 2904. Patch test values for data collected on these days with HSL 2904 is applied via SVP1 within the Caris HVF and corrected in post-processing while correcting for sound speed. Other deviations of patch test values applied other than within the POS MV software at acquisition are stated within this section.

A patch test was conducted incorrectly on 5/23/2109 for 2904. Data collected on 5/23/2019 was collected with incorrect settings applied within POS MV. As a result, a 0.302 roll offset artifact was observed in four days of data from Project OPR-E350-TJ-19. The correct offset value of 0.302 was applied to the data collected with the incorrect patch test values via SVP2 within the Caris HVF for 2904 for those four days, and corrected in post-processing while correcting for sound speed. Additional roll offset artifacts were observed in the data for Project OPR-E350-TJ-19 after a correct patch test was conducted. A 0.27° roll offset was applied to 2904 data acquired from 5/23/2019 to 6/1/2019, and a roll offset of 0.11 ° was applied to 2904 data acquired from 6/1/2019 to 7/15/2019. These additional roll offsets were applied via SVP2 within the Caris HVF for 2904, and corrected in post-processing while correcting for sound speed. These additional roll values were added to the POS MV offsets and subsequently set to zero within the HVF for data acquired after 7/15/2019.

Additional roll offset artifacts were observed in 2903 data from Project OPR-D304-TJ-10. A 0.10° roll offset was applied to data acquired on 10/24/2019. The additional roll offset was applied via SVP2 within the Caris HVF for 2903, and corrected in post-processing while correcting for sound speed.

A vertical difference of 50cm was observed in the SBES data from 2903 when compared with the reference surface from 2904's EM2040 MBES (Multibeam Echo Sounder) data. After further investigation, the offset was attributed to the Draft and Index value within the ODOM controller software eChart. The ODOM manual states that the bar check procedure is used to correct for sound speed in case a sound speed probe is not used. Sound speed was then corrected for during post-processing, resulting in double correction for sound speed. Within the Caris HVF, the reciprocal value of the Draft and Index value was used in order to back out the values from the raw data. The value set under SVP1 within the HVF is -0.49.

All calibration reports can be found in the appendices.

B.3.1.1 System Alignment Correctors

<table>
<tr><td><i>Vessel</i></td><td>2903</td></tr>
<tr><td><i>Echosounder</i></td><td>Kongsberg EM2040</td></tr>
<tr><td><i>Date</i></td><td>2019-06-06</td></tr>
<tr><td><i>Patch Test Values</i></td><td>
<table>
<tr><td></td><td><i>Corrector</i></td><td><i>Uncertainty</i></td></tr>
<tr><td><i>Transducer Time Correction</i></td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
<tr><td><i>Navigation Time Correction</i></td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
<tr><td><i>Pitch</i></td><td>0.000 degrees</td><td>0.020 degrees</td></tr>
<tr><td><i>Roll</i></td><td>0.000 degrees</td><td>0.020 degrees</td></tr>
<tr><td><i>Yaw</i></td><td>0.000 degrees</td><td>0.020 degrees</td></tr>
<tr><td><i>Pitch Time Correction</i></td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
<tr><td><i>Roll Time Correction</i></td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
<tr><td><i>Yaw Time Correction</i></td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
<tr><td><i>Heave Time Correction</i></td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
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<tr><td><i>Date</i></td><td>2019-06-06</td></tr>
<tr><td><i>Patch Test Values</i></td><td>
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<tr><td></td><td><i>Corrector</i></td><td><i>Uncertainty</i></td></tr>
<tr><td><i>Transducer Time Correction</i></td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
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<tr><td><i>Yaw Time Correction</i></td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
<tr><td><i>Heave Time Correction</i></td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
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<table>
<tr><td><i>Vessel</i></td><td>2903</td></tr>
<tr><td><i>Echosounder</i></td><td>Teledyne Odom Echotrac CV200</td></tr>
<tr><td><i>Date</i></td><td>2019-06-01</td></tr>
<tr><td><i>Patch Test Values</i></td><td>
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<tr><td><i>Transducer Time Correction</i></td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
<tr><td><i>Navigation Time Correction</i></td><td>0.000 seconds</td><td>0.001 seconds</td></tr>
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C. Data Acquisition and Processing

C.1 Bathymetry

C.1.1 Multibeam Echosounder

Data Acquisition Methods and Procedures

All multibeam data are logged using Kongsberg Seafloor Information System (SIS) in the .all file format.

During acquisition aboard 2903 and 2904 the hydrographer:

- Monitors the SIS interface for errors and data quality

- Monitors the SIS interface for indication of sound speed changes requiring a cast, and conducts casts as necessary

- Monitors the Hysweep interface in HYPACK

- Monitors the vessel speed and requests the bridge to adjust as necessary to ensure density and coverage specifications are met

Data Processing Methods and Procedures

The following workflow applies to 2903 and 2904 for Applanix RTX with Kongsberg EM2040:

1) Create SBET and RMS files in POSPac MMS.
2) Convert raw .all data to Caris HDCS format
3) Load Delayed Heave
4) Import ancillary data: SBET and RMS
5) Apply sound speed correctors
6) Compute GPS Tides using the provided VDatum SEP model.
7) Merge; use GPS Tides.
8) Compute Total Propagated Uncertainty (TPU)
9) Create a Combined Uncertainty and Bathymetry Estimator (CUBE) surface
10) Data quality control and analysis

The following options are selected when CUBE surfaces were created:

- Surface Type – CUBE

- IHO S-44 Order – Order 1a

- Include status – check Accepted, Examined and Outstanding

- Disambiguation method - Density & Locale (this method selects the hypothesis that contains the greatest number of soundings and is also consistent with neighboring nodes).

- Advanced Configuration – Dependent upon the surface resolution (Object detection v. complete coverage)

Preliminary data cleaning is performed daily. Typically, the reviewer only cleans out the most blatant of fliers and blowouts, leaving the final cleaning to a later date when all data is consolidated. Depth, Standard Deviation, Hypothesis Strength and Hypothesis Count models derived from the acquisition operation day surface are viewed with appropriate vertical exaggeration and a variety of sun illumination angles to highlight potential problem areas. Based on this analysis the most appropriate cleaning method is selected as follows:

- Subset Mode is the default tool selected due to its ability to quickly compare large numbers of soundings with adjacent or overlapping data for confirmation or rejection. Subset mode also excels with the assessment of possible features, disagreement between overlapping lines, and crossline comparison. Subset Mode can be used to visually enhance patterns and anomalies in CUBE surfaces.

- Swath Editor is useful for burst noise, multipath, and other "gross fliers" which are specific to a particular line or lines, and most easily removed in this mode. Additionally, when it was felt that the quality of the data was reduced due to environmental conditions such as rough seas or extreme variance in sound speed, data were filtered on a line by line basis to a lesser swath width to ensure data quality.

Once all the data is cleaned, the CUBE surfaces are examined to ensure complete coverage and to plan additional lines or polygons to fill “holidays.”

C.1.2 Single Beam Echosounder

Data Acquisition Methods and Procedures

eChart software was used at acquisition to turn the sonar on and off. A bar check was performed and values saved in the eChart software with an index value of 0.21 and a draft value of 0.7m. Hypack was used to collect single beam echo sounder data in the .RAW format. See section B.3.1 System Alignment Methods and Procedures for alignment and configuration of the single beam echo sounder due to issues with the index value and draft value in the eChart software.

Data Processing Methods and Procedures

One workflow exists for SBES and is outlined below.

Applanix RTX with Teledyne Odom Echotrac CV200:

1) Create SBET and RMS files in POSPac MMS.
2) Convert raw .RAW data to Caris HDCS format
3) Load Delayed Heave
4) Import ancillary data: SBET and RMS
5) Apply sound speed correctors
6) Compute GPS Tides using the provided VDatum SEP model.
7) Merge; use GPS Tides.
8) Compute Total Propagated Uncertainty (TPU)
9) Create a Combined Uncertainty and Bathymetry Estimator (CUBE) surface
10) Data quality control and analysis

Preliminary data cleaning is performed daily. The most appropriate cleaning method is selected as follows:

- Single Beam Editor is the default tool used. Single beam Editor is useful for "gross fliers" which are specific to a particular line or lines, and most easily removed in this mode.

C.1.3 Phase Measuring Bathymetric Sonar

Phase measuring bathymetric sonar bathymetry was not acquired.

C.1.4 Gridding and Surface Generation

C.1.4.1 Surface Generation Overview

After initial processing, the bathymetric data are gridded into BASE surfaces using the Combined Uncertainty and Bathymetry Estimator (CUBE) algorithm. This type of surface calculates a horizontal and vertical uncertainty for each sounding, derived from the combined uncertainty from each of the sensors that contributes data to the sounding (e.g water levels, tide zoning, attitude sensor error, navigation sensor horizontal position error, and sound speed profile error). Individual soundings are then propagated to grid nodes, which takes on a depth value as well as an uncertainty value based on all the soundings that contribute to the node. The influence of a sounding on a grid node is limited to 0.354 times the grid resolution. Resolution is determined by the Project Instructions and the HSSD 2019.

On a daily bases Single Resolution (SR) surfaces are created at the required resolution for holiday planning and data "cleaning" in order to efficiently maximize the operational time frame. For the final submission of the project a Variable Resolution (VR) surface is created and submitted as the deliverable product. When creating VR surfaces, the estimation method typically used is "Ranges". If significant "holidays" are observed in the CUBE surface after creation that is not observed within the data a new CUBE surface is created with the "Calder-Rice Density" estimation method with the finest resolution set at the required resolution as specified by the Project Instructions and the HSSD 2019.

SBES is gridded as a SR CUBE surface at 4m resolution. SBES surfaces include the Shoal child layer.

C.1.4.2 Depth Derivation

Chart-datum depths are derived using tidal models provided to the field unit, usually in the form of a VDatum separation model that corrects for height disagreements between the acquisition datum (Ellipsoidal) and chart datums (Mean Lower Low Water). Anomalous data (fliers) may induce false gridded depth estimates and draw gridded depth nodes away from reliable soundings. Flier Finder within QC Tools is used to help identify such anomalous soundings for the hydrographer to flag the soundings from use with the submitted sounding dataset.

C.1.4.3 Surface Computation Algorithm

MBES data are gridded using the CUBE algorithm. Resolution is dictated by the Project Instructions, as well as section 5.2.2 of the HSSD 2019. The disambiguation method used is always Density and Local. The settings used for Capture Distance Scale, Horizontal Error Scale, and Capture Distance Minimum are those listed in section 4.2.1.1.1.1 of the 2014 FPM and are provided by the NOAA Office of Coast Survey (OCS) in a customized CUBE parameters file (CUBEParams_NOAA_2019.xml). After creation, Uncertainty and CUBE surfaces go through a quality control process. During this process, the Depth, Uncertainty, Standard Deviation, and Density child layers are examined for compliance with NOAA specifications. After the surfaces pass quality control, they are finalized. Uncertainty values for finalized surface come from the greater of either Uncertainty, or Standard Deviation.

The Advanced options configuration is employed when creating a VR surface. Estimation method parameters for Density-based CARIS VR Surfaces have the estimation method: "Ranges", with the range/resolution file set to NOAA_DepthRanges_CompleteCoverage_2019.txt or NOAA_DepthRanges_ObjectDetection_2019.txt depending on the coverage requirements. If significant "holidays" are observed in the CUBE surface after creation that is not observed within the data a new CUBE surface is created with the "Calder-Rice Density" estimation method with the finest resolution set at the required resolution. NOAA OCS has created and provided a customized CUBE parameters file (CUBEParams_NOAA_2019.xml) with new CUBE parameters that are required for each grid resolution. When creating CUBE surfaces, the user is provided an option to select parameters configuration based on the surface resolution required for the survey, which optimizes the performance of the CUBE algorithm. The Population parameters for CARIS VR surfaces is CUBE, with the IHO Order selected and set to "S44 Order 1a", and the CUBE configuration is "NOAA_VR" for a given surface.

C.2 Imagery

C.2.1 Multibeam Backscatter Data

Data Acquisition Methods and Procedures

MBES backscatter data are logged via SIS and are included in the MBES files (.all format) by default.

The absorption coefficient depends upon depth, water temperature, salinity and frequency. A correct value is important with respect to the validity of the bottom backscatter data measured by the system.

The normal incidence sector, (angle from nadir in degrees), defines the angle at which the bottom backscatter can be assumed not to be affected by strong increase at normal incidence. For seabed imaging, it is important to adjust this angle to minimize angle-dependent amplitude variation. The value for this parameter is kept at 15 degrees unless otherwise documented.

The parameters set in SIS for pulse type is set to auto with FM disabled. The intensity values of the backscatter return are effected by sudden changes to the pulse length. Switching between pulse lengths mid-line is not ideal for backscatter acquisition and it is recommended not to use Auto for the pulse length when acquiring backscatter. With the operational depths that THOMAS JEFFERSON and her launches operate in the default pulse length selected by Auto is Short CW and there is no indication that there was use of a different pulse length within the project.

Data Processing Methods and Procedures

All acquired backscatter data are processed into a mosaic and delivered to Atlantic Hydrographic Branch. All processing of backscatter is done using the FMGT (7.9.2) module of the QPS Fledermaus software package in accordance with OCS standard data processing methods using standard operating procedure OCSQMS_SOP_Backscatter_Processing.pdf dated August 7, 2018.

The following is the general workflow for creating backscatter imagery:

1) A new project is created for each sheet and each vessel and each sonar frequency. Meta data within the .all files ensures that sonar-specific characteristics are captured during mosaic processing.

2)Lines are imported into FMGT. One mosaic is created per boat and frequency (200kHz, 300kHz, and 400kHz), meaning three mosaics are created, one for each frequency.

3) Create a mosaic. Crosslines are not needed in the mosaic and are deselected. Mosaic gridding resolution is set to 1m. The product is exported as a floating point GeoTIFF grid with a value for no data set to -9999.

C.2.2 Side Scan Sonar

Data Acquisition Methods and Procedures

Side scan sonar data collected with the Klein 5000MKII-B SSS are logged using Klein SonarPro, in the .SDF format.
Data collected with the Edgetech 4200 SSS were logged in Edgetech Discover in .XTF format.
During acquisition the hydrographer:

- Monitors range, heading, pitch, roll, latitude, longitude, speed, pressure, and temperature. SSS towfish on HSL 2903 and 2904 are in the Hull mounted configuration and towfish height can not be adjust.

Data Processing Methods and Procedures

1) Convert raw SSS data using Caris SIPS;
2) Scan Navigation and Attitude data, flagging erroneous data as rejected;
3) Re-compute towfish navigation. This is when tow point offsets and horizontal layback is applied to the data;
4) A primary reviewer scans each line for significant contacts;
5) A secondary reviewer makes an independent check-scan of all lines, verifying contacts and checking for missed contacts;
6) If the Project Instructions call for 200% Side Scan coverage, the scanners check correlation of contacts between 100% and 200% coverage;
7) Correlation is also used to reveal systematic errors, particularly if a contact shows up on lines collected in opposite or orthogonal directions;
8) Create individual mosaics for 100% and 200% coverage. Examine for coverage;
9) If necessary, create a holiday line plan.

C.2.3 Phase Measuring Bathymetric Sonar

Phase measuring bathymetric sonar imagery was not acquired.

C.3 Horizontal and Vertical Control

C.3.1 Horizontal Control

C.3.1.1 GNSS Base Station Data

GNSS base station data was not acquired.

C.3.1.2 DGPS Data

DGPS data was not acquired.

C.3.2 Vertical Control

C.3.2.1 Water Level Data

Data Acquisition Methods and Procedures

Raw GNSS-INS observables data are logged through POSView for 2903 and 2904.

Data Processing Methods and Procedures

THOMAS JEFFERSON reduces all data to chart datum via Ellipsoidally Referenced Survey (ERS) workflows for all surveys.

GPS Tides:

The ‘Compute GPS Tides’ process in Caris HIPS is the primary means by which bathymetric data are reduced to chart datum. The Compute GPS Tides step references all MBES data to an ellipsoid and then applies a separation model to the ellipsoidally referenced data to achieve reduction to chart datum. The separation model is an XYZ surface that represents the difference between the ellipsoid and chart datum for the a given geographic area. The XYZ separation model used for typical NOAA workflows is delivered as a Caris CSAR file and represents the difference between the WGS84 ellipsoid and MLLW at a given location. All separation models for waters in which THOMAS JEFFERSON operates are derived from the National Geodetic Survey Vertical Datum (VDatum) program. Separation models are usually generated, approved and disseminated by the Hydrographic Survey Division Operations Branch.

GNSS positioning methods employed to meet ERS specifications include the methods described below:

Raw GNSS-INS observables data are logged through POSView can be post-processed in POSPac MMS to provide a trajectory solution that can be applied to MBES data in CARIS HIPS. Post-Processed Trimble CenterPoint real-time extended is the standard practice for 2903 and 2904.

Inertially aided Fusion Post-Processed real-time extended:

During post-processing, horizontal positioning can be shifted to an Inertially aided Fusion Post-Processed real-time extended (Trimble PP-RTX) solution. The solution is created by combining GPS/GNSS satellite ephemeris and clock data with position information downloaded from a network of Continually Operating Reference Stations (CORS). The resulting position data are corrected for the effects of atmospheric interference on the GPS signal. The corrected GPS position is then combined with the vessel's inertial data using the POSPac MMS program to create a Smoothed Best Estimate of Trajectory (SBET). The resulting position can be used to apply higher quality navigation information to the processed data.

C.3.2.2 Optical Level Data

Optical level data was not acquired.

C.4 Vessel Positioning

Data Acquisition Methods and Procedures

As described in Section A.5 of this document.

Data Processing Methods and Procedures

As described in Section C.3 of this document.

C.5 Sound Speed

C.5.1 Sound Speed Profiles

Data Acquisition Methods and Procedures

2903 and 2904 both use Sea-Bird SBE 19plus CTDs to collect sound speed profiles. Casts are generally taken at 2-4 hour intervals. Casts are also conducted when changing survey areas or when a change of weather, tide, or current warrant. The launch crew also monitors the real time display of the Reson SVP-71 sound speed probe for significant changes in the surface sound speed.

The following procedure is followed when conducting manual CTD casts with the SBE 19plus: The instrument is lowered into the water and submerged just below the water's surface for about 1 minute to allow air to escape the salinity cell. The instrument is lowered at the rate of free fall. The instrument is lowered slowly (in some cases, much less than 1 meter/second) through the first 5-10 meters of water in order to accurately sample the sound speed for areas with lenses of fresh water or other complex sound speed variation near the surface.

Data Processing Methods and Procedures

Downloading and processing of sound speed data are performed using Sound Speed Manager v.2019.2.5, part of the HSTB-supplied Pydro Explorer v19.4(r10747) program suite. Sound speed values are calculated using the UNESCO equation (Fofonoff and Millard, 1983). Processed profiles are sent to SIS for realtime beam control. In addition, both raw and processed CTD files are archived and submitted to Atlantic Hydrographic Branch as part of the survey submission package.

All sound speed profiles for CARIS are concatenated into a vessel-wide or survey-wide files in order of ascending time and date. These concatenated file(s) are applied to all HDCS data acquired with "Nearest in distance within time (4 Hours)" selected under the "Profile selection Method".

Processed sound speed data are applied to the MBES data in Caris HIPS.

C.5.2 Surface Sound Speed

Data Acquisition Methods and Procedures

2903 and 2904 use Reson SV-71 probes to acquire sound speed at their respective transducer faces.

Sound speed values are applied in real-time to all MBES systems to provide refraction corrections to flat-faced transducers.

The accuracy of each surface sound speed device is checked against the closest CTD data point after every CTD cast.

Data Processing Methods and Procedures

Surface sound speed data are logged directly into Kongsberg raw data files. Surface sound speed data are not typically processed after the time of acquisition.

C.6 Uncertainty

C.6.1 Total Propagated Uncertainty Computation Methods

Total Propagated Uncertainty (TPU) is calculated in Caris HIPS using the 'Compute TPU tool'.

The uncertainty values for each input into the TPU model can come from one of three sources: Real-time, Static, or Vessel. Real-time values are provided from the sensor or processing package (e.g. POSPac RMS values). Static values are those entered manually into the Compute TPU dialog (e.g. tidal zoning uncertainty and sound speed measurement uncertainties). Static values are documented in each Descriptive Report. Vessel values are taken from the HVF if no realtime or static values are available.

Uncertainty values entered into the HVF for the multibeam and positioning systems are derived from manufacturer specifications sheets for each sensor and from values set forth in section 4.2.3.8 and Appendix 4 - Caris HVF Uncertainty Values of the 2014 FPM.

Sound speed static values are derived from the guidance in the FPM, manufacturer specifications and annual calibration results.

Tide correction uncertainty values for the ERS work flow are static values specified in the Project Instructions.

Ellipsoid height uncertainty values for ellipsoid measurements derived from 5P or Trimble PP-RTX work flows are applied as real-time values from RMS files. Kongsberg systems provide uncertainty statistics that are recorded in raw MBES files.

All offsets, correctors, and values used in TPU calculation that are stored in the HVF file can be found in the included Appendix Folder, HVF Reports. These HVF Reports are output from the Caris HVF Editor in a plain text document readable anywhere, and include all of the requested values for the DAPR necessary to reproduce an HVF.

See included HVFs for information on vessel uncertainty values.

C.6.2 Uncertainty Components

C.6.2.1 A Priori Uncertainty

A priori uncertainty was not applied.

C.6.2.2 Real-Time Uncertainty

Vessel	*Description*
2903	As discussed above.
2904	As discussed above.

C.7 Shoreline and Feature Data

Data Acquisition Methods and Procedures

The following workflow is used to develop and verify features:

1) Potentially significant features are initially identified and inspected in Caris HIPS (both MBES and SSS contacts).

2) A development area polygon or point feature is exported from HIPS; a line plan is created using HIPS or ArcMap if needed.

3) Object Detection level MBES data are collected over all MBES and/or SSS contacts, SBES designated soundings, and all possible shoal areas.

Quality of data are controlled through:

1) Real time monitoring during acquisition to ensure that all features are covered by near nadir beams.

2) Inspection of the CUBE surface's Density, Standard Deviation, and Uncertainty layers.

3) All developments are examined for significance. Objects found to be significant are flagged with a designated sounding, and become part of the Final Feature File.

Data Processing Methods and Procedures

Feature verification begins during initial data processing. Both SSS and MBES data are processed following the conclusion of daily acquisition operations or at regular intervals (typically daily) for continuous ship operations. Significant contacts are identified and noted during initial processing. All significant contacts are then developed using a MBES. Significant features found in MBES data are flagged as 'designated soundings', then imported into Caris BASE Editor or HIPS. Inside BASE Editor, each significant contact is given an S-57 attribution, and the hydrographer recommends charting action. The final deliverable is a Final Feature File (FFF) in .000 format.

C.8 Bottom Sample Data

Data Acquisition Methods and Procedures

Hydrographic Survey Division Operations Branch typically provides the field unit with a number of recommended bottom sample sites. Proposed sample sites are encoded as S-57 SPRINGS and are provided in files distributed with the Project Instructions for the survey.

Bottom sample acquisition typically occurs after the majority of main-scheme MBES acquisition has completed. Bathymetric surfaces, backscatter surfaces and SSS intensity mosaics are examined to confirm the validity of the proposed sample sites. Sample sites may be moved or eliminated depending on field conditions. Samples are collected by launch or ship using one of the bottom samplers described in the equipment section of this report.

Imagery of the bottom type is collected in accordance with HSSD 2019 requirements.

Physical sample bottom material is discarded after field analysis is complete.

Data Processing Methods and Procedures

Samples are analyzed for sediment type and classified with S57 attribution.

The NATSUR S-57 attribute for a sample site is characterized as “unknown” in the event that no sample is obtained after three collection attempts.

S-57 attribution is conducted in Caris HIPS or BASE Editor.

Imagery and attribution is included as a feature file media attachment.

All bottom samples are processed in accordance with HSD HTD 2018-4_Bottom Sample Drop Camera Imagery.

D. Data Quality Management

D.1 Bathymetric Data Integrity and Quality Management

D.1.1 Directed Editing

On a daily bases Single Resolution (SR) surfaces are created at the required resolution for holiday planning and data "cleaning" in order to efficiently maximize operational time frames. The Flier Finder v8, Holiday Finder v4, and Grid QA v5 program in QC Tools v3.1.6 that is included with Pydro Explorer v19.4(r10747) is used for data integrity and quality management. The Flier Finder v8 program is used to direct cleaning of potential "fliers" in the bathymetric surface data. This algorithm contributes to detect fliers as early as possible in the quality control process. Its initial implementation scans gridded bathymetry and flags abrupt depth changes as per user-set criteria. After data "cleaning" with direction from Pydro based tools, all statistics layers generated by the Caris CUBE implementation are used (including uncertainty, hypothesis count, hypothesis strength, and standard deviation) to verify that the Pydro Tools did not grossly miss obvious "fliers".

D.1.2 Designated Sounding Selection

Designated soundings are selected in accordance with HSSD 2019, except where noted in DR.

D.1.3 Holiday Identification

Holidays within the CUBE surface are identified using the Holiday Finder v4 program in QC Tools v3.1.6, included in Pydro Explorer v19.4(r10747). The tool compares the CUBE surface to coverage requirements set forth by HSSD 2019. The standard tools included in ArcGIS 10.6.1 are also used for holiday identification, primarily to inspect SSS mosaics. In addition to automated tools, all surfaces are also visually inspected.

D.1.4 Uncertainty Assessment

Total Vertical Uncertainty and Total Horizontal uncertainty surface statistics of the CUBE surface is calculated using the Grid QA v5 program in QC Tools v3.1.6, included in Pydro Explorer v19.4(r10747). The tool then compares the statistics with the surface requirements set forth by HSSD 2019.

Statistics layers generated by the Caris CUBE implementation are visually inspected.

D.1.5 Surface Difference Review

D.1.5.1 Crossline to Mainscheme

The Crossline to Mainscheme Analysis is conducted using the Gridded Surface Comparison program, included in Pydro Explorer v19.4(r10747). CUBE surfaces of crossline data and mainscheme data are differenced, each gridded at the required resolution set forth by the Project Instructions and HSSD 2019. The resulting statistics are output in an easy-to-read Gaussian distribution chart with the mean, mode, and standard deviation values.

D.1.5.2 Junctions

The Junction Analysis is conducted using the Gridded Surface Comparison program, included in Pydro Explorer v19.4(r10747). A CUBE surface of the data, gridded at the required resolution set forth by the Project Instructions and HSSD 2019, is differenced with the .bag surface that is provided with the Project Instructions. The resulting statistics are output in an easy-to-read Gaussian distribution chart with the mean, mode, and standard deviation values. The Gridded Surface Comparison program may not be able to use older formates of surfaces that have an Elevation child layer. In these instances, a difference surface is created between the CUBE surface and the .bag surface in Caris 10.4 HIPS, and statistics are computed from the difference layer. The resulting statistics are output in an easy-to-read Gaussian distribution chart with the mean, mode, and standard deviation values.

D.1.5.3 Platform to Platform

The Platform to Platform Analysis is conducted using the Gridded Surface Comparison program, included in Pydro Explorer v19.4(r10747). CUBE surfaces of HSL data and ship data are differenced, each gridded at the required resolution set forth by the Project Instructions and HSSD 2019. The resulting statistics are output in an easy-to-read Gaussian distribution chart with the mean, mode, and standard deviation values.

D.2 Imagery data Integrity and Quality Management

D.2.1 Coverage Assessment

Coverage is assessed in accordance with HSSD 2019.

Automated and visual methods are used to inspect surface coverage: ArcGIS tools are used to automatically identify coverage deficiencies; surfaces are inspected against brightly colored backgrounds for visible gaps in coverage.

CUBE statistical surfaces that show gridded node density are used to visually assess surfaces for compliance with bathymetric surface node density requirements.

The Grid QA v5 program in QC Tools v3.1.6, included in Pydro Explorer v19.4(r10747) is used to statistically inspect CUBE surfaces for compliance with bathymetric surface node density requirements.

D.2.2 Contact Selection Methodology

Contacts are selected in accordance with HSSD 2019.

Visual inspection of all SSS data are conducted in CARIS SIPS by multiple scanners that include the initial processor, a check scanner, and the sheet manager for a minimum of three scans for contact detection.

E. Approval Sheet

As Chief of Party, I have ensured that standard field surveying and processing procedures were adhered to during these projects in accordance with the Hydrographic Surveys Specifications and Deliverables (2017 ed) and the Field Procedures Manual for Hydrographic Surveying (2014 ed).

I acknowledge that all of the information contained in this report is complete and accurate to the best of my knowledge.

Approver Name	Approver Title	Date	Signature
CDR Briana W. Hillstrom	Commanding Officer	05/06/2020	HILLSTROM.BRIANA.WELTON.1267667531 Digitally signed by HILLSTROM.BRIANA.WELTON.1267667531 Date: 2020.05.07 14:38:15 -04'00'
LT Calandria DeCastro	Field Operations Officer	05/06/2020	DECASTRO.CALANDRIA.MALVINA.1468902156 Digitally signed by DECASTRO.CALANDRIA.MALVINA.1468902156 Date: 2020.05.07 16:15:07 -04'00'
Joshua Hiteshew	Chief Hydrographic Survey Technician	05/06/2020	HITESHEW.JOSHUA.TAYLOR.1537939652 Digitally signed by HITESHEW.JOSHUA.TAYLOR.1537939652 Date: 2020.05.13 13:44:16 Z

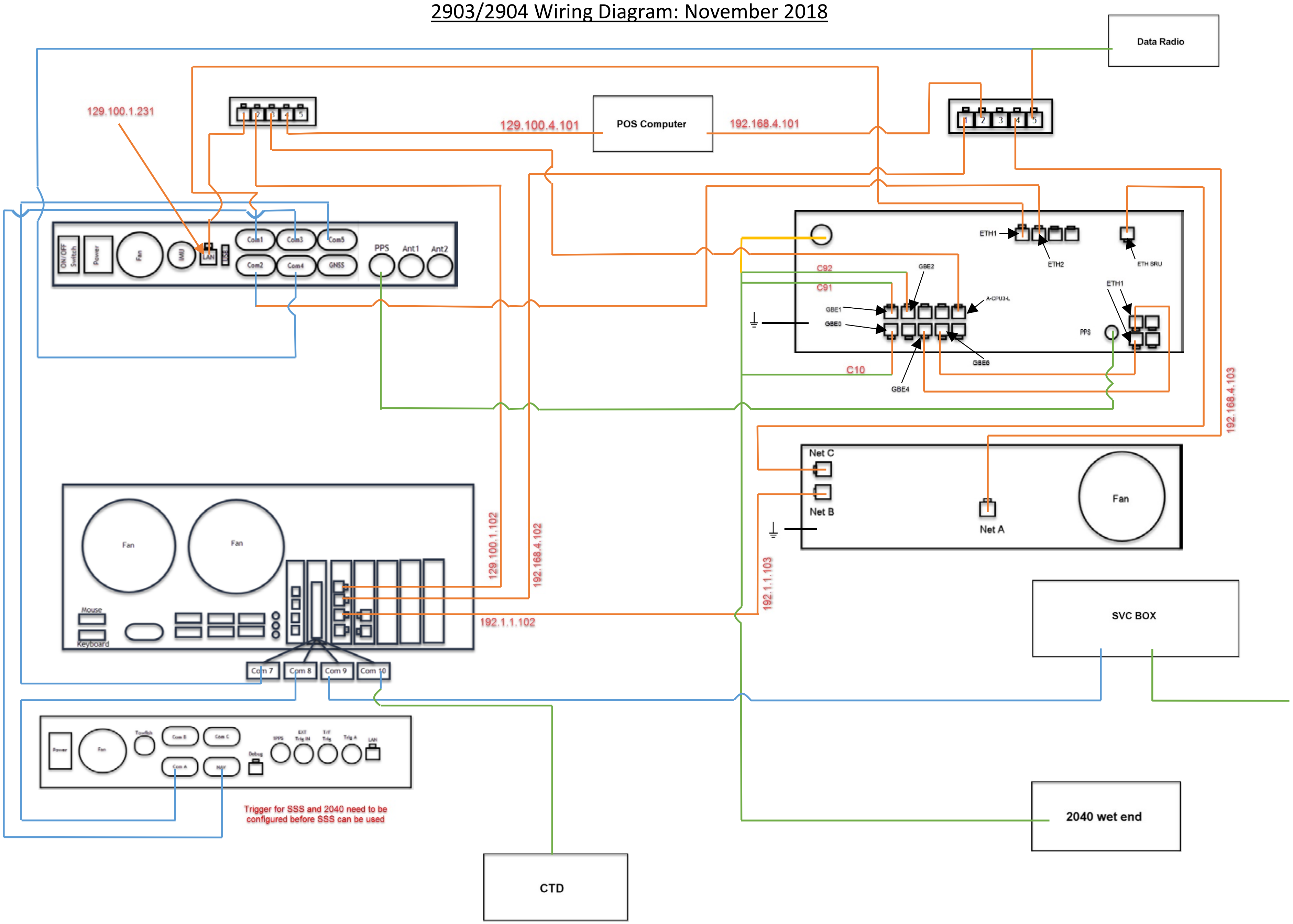
List of Appendices:

Mandatory Report	***File***
Vessel Wiring Diagram	OPR-E350-TJ-19_DAPR_Appendices.pdf
Sound Speed Sensor Calibration	OPR-E350-TJ-19_DAPR_Appendices.pdf
Vessel Offset	OPR-E350-TJ-19_DAPR_Appendices.pdf
Position and Attitude Sensor Calibration	OPR-E350-TJ-19_DAPR_Appendices.pdf
Echosounder Confidence Check	OPR-E350-TJ-19_DAPR_Appendices.pdf
Echosounder Acceptance Trial Results	OPR-E350-TJ-19_DAPR_Appendices.pdf

Additional Report	***File***
HVF Values	OPR-E350-TJ-19_DAPR_Appendices.pdf
HSRR Documentation	OPR-E350-TJ-19_DAPR_Appendices.pdf

Wiring diagrams

2903/2904 Wiring Diagram: November 2018



Trigger for SSS and 2040 need to be configured before SSS can be used

Sound Speed Sensor Calibration Reports

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SENSOR SERIAL NUMBER: 4487
CALIBRATION DATE: 24-Feb-19

SBE 19plus CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

```
g =  -1.020698e+000
h =   1.392822e-001
i =  -1.386436e-004
j =   3.069981e-005
```

```
CPcor = -9.5700e-008
CTcor =  3.2500e-006
```

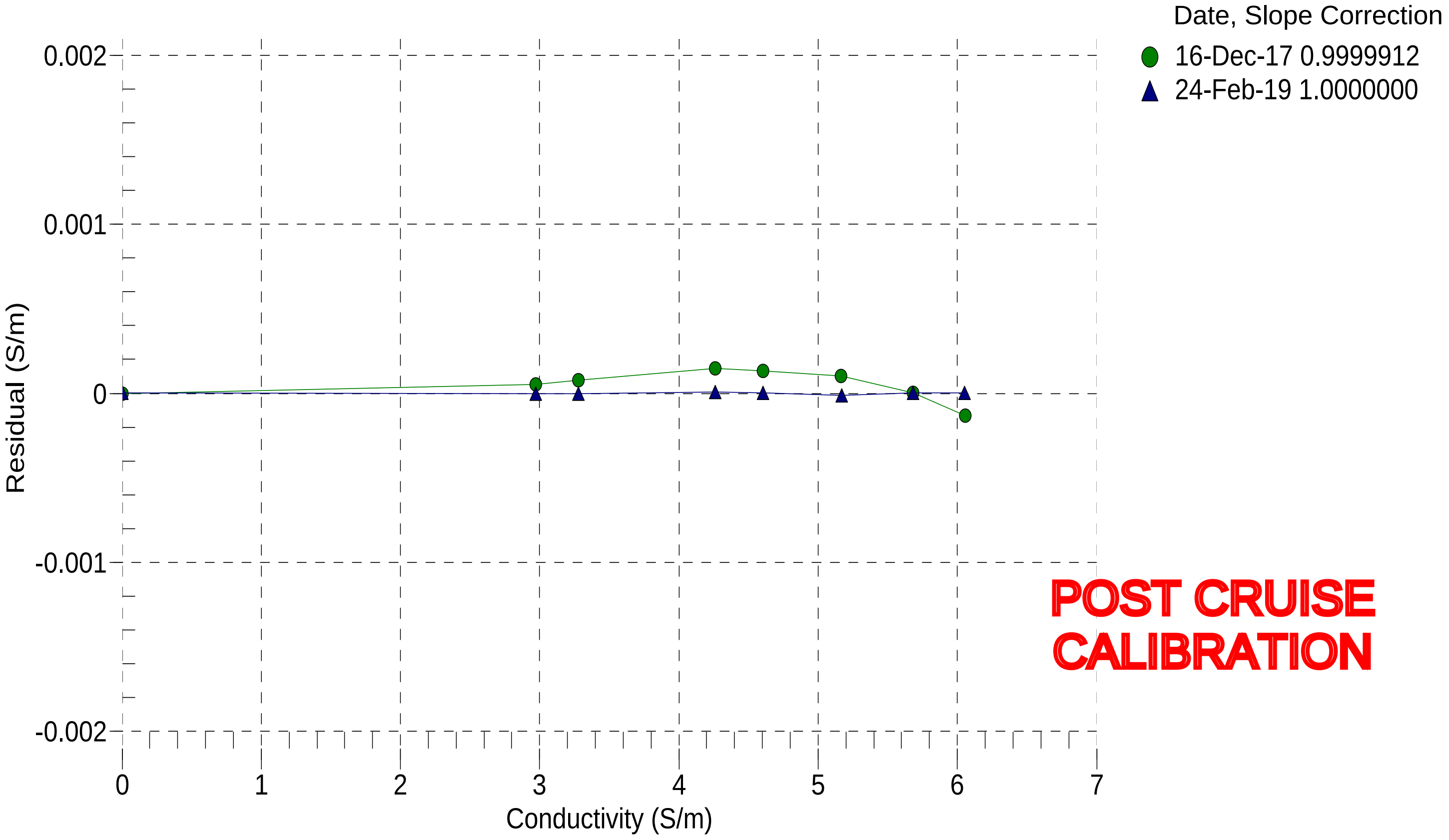
BATH TEMP (° C)	BATH SAL (PSU)	BATH COND (S/m)	INSTRUMENT OUTPUT (Hz)	INSTRUMENT COND (S/m)	RESIDUAL (S/m)
22.0000	0.0000	0.00000	2708.54	0.0000	0.00000
1.0000	34.7695	2.97235	5351.69	2.9723	-0.00000
4.5000	34.7496	3.27905	5552.66	3.2790	-0.00000
15.0000	34.7074	4.25967	6150.53	4.2597	0.00001
18.5000	34.6980	4.60437	6347.04	4.6044	0.00000
24.0699	34.6873	5.16876	6655.98	5.1688	-0.00001
29.0000	34.6802	5.68253	6924.92	5.6825	0.00000
32.5000	34.6712	6.05354	7112.62	6.0535	0.00000

f = Instrument Output (Hz) / 1000.0

t = temperature (°C); p = pressure (decibars); δ = CTcor; ε = CPcor;

Conductivity (S/m) = $(g + h * f^2 + i * f^3 + j * f^4) / (1 + \delta * t + \varepsilon * p)$

Residual (Siemens/meter) = instrument conductivity - bath conductivity



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SENSOR SERIAL NUMBER: 4487
CALIBRATION DATE: 13-Feb-19

SBE 19plus PRESSURE CALIBRATION DATA
508 psia S/N 2837

COEFFICIENTS:

```
PA0 =       7.992141e-002
PA1 =       1.556523e-003
PA2 =       7.918375e-012
PTEMPA0 = -7.374525e+001
PTEMPA1 =  4.826346e+001
PTEMPA2 = -1.624830e-001
```

```
PTCA0 =  5.241642e+005
PTCA1 =  4.662898e+000
PTCA2 = -1.058809e-001
PTCB0 =  2.498675e+001
PTCB1 = -5.000000e-005
PTCB2 =  0.000000e+000
```

PRESSURE SPAN CALIBRATION

PRESSURE (PSIA)	INSTRUMENT OUTPUT (counts)	THERMISTOR OUTPUT (volts)	COMPUTED PRESSURE (PSIA)	RESIDUAL (%FSR)
14.43	533425.0	2.0	14.42	-0.00
104.69	591376.0	2.0	104.66	-0.01
204.72	655559.0	2.0	204.66	-0.01
304.73	719698.0	2.0	304.67	-0.01
404.71	783807.0	2.0	404.69	-0.00
504.73	847879.0	2.0	504.72	-0.00
404.68	783826.0	2.0	404.72	0.01
304.67	719726.0	2.0	304.71	0.01
204.66	655582.0	2.0	204.70	0.01
104.66	591408.0	2.0	104.71	0.01
14.42	533434.0	2.0	14.43	0.00

THERMAL CORRECTION

TEMP (°C)	THERMISTOR OUTPUT (volts)	INSTRUMENT OUTPUT (counts)
32.50	2.22	533770.37
29.00	2.14	533780.64
24.07	2.04	533784.13
18.50	1.92	533781.67
15.00	1.85	533778.01
4.50	1.63	533750.68
1.00	1.56	533737.62

TEMPERATURE (°C)	SPAN
-5.00	24.99
35.00	24.98

y = thermistor output (volts)

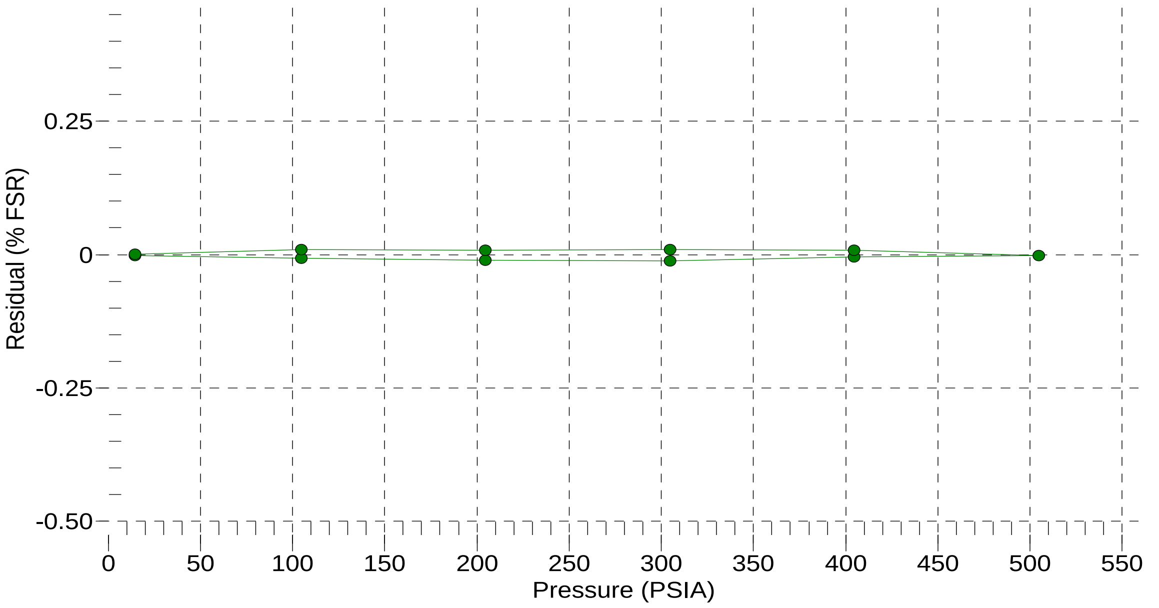
$t = PTEMPA0 + PTEMPA1 * y + PTEMPA2 * y^2$

$x = \text{instrument output} - PTCA0 - PTCA1 * t - PTCA2 * t^2$

$n = x * PTCB0 / (PTCB0 + PTCB1 * t + PTCB2 * t^2)$

$\text{pressure (PSIA)} = PA0 + PA1 * n + PA2 * n^2$

Residual (%FSR) = (computed pressure - true pressure) * 100 / Full Scale Range



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SENSOR SERIAL NUMBER: 4487
CALIBRATION DATE: 24-Feb-19

SBE 19plus TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

COEFFICIENTS:
a0 = 1.211206e-003
a1 = 2.622884e-004
a2 = -1.724221e-007
a3 = 1.521394e-007

BATH TEMP (° C)	INSTRUMENT OUTPUT (counts)	INST TEMP (° C)	RESIDUAL (° C)
1.0000	713444.898	1.0000	0.0000
4.5000	638133.356	4.5000	-0.0000
15.0000	447155.695	15.0002	0.0002
18.5000	394891.407	18.4997	-0.0003
24.0699	322418.254	24.0698	-0.0001
29.0000	268198.475	29.0003	0.0003
32.5000	234737.712	32.4999	-0.0001

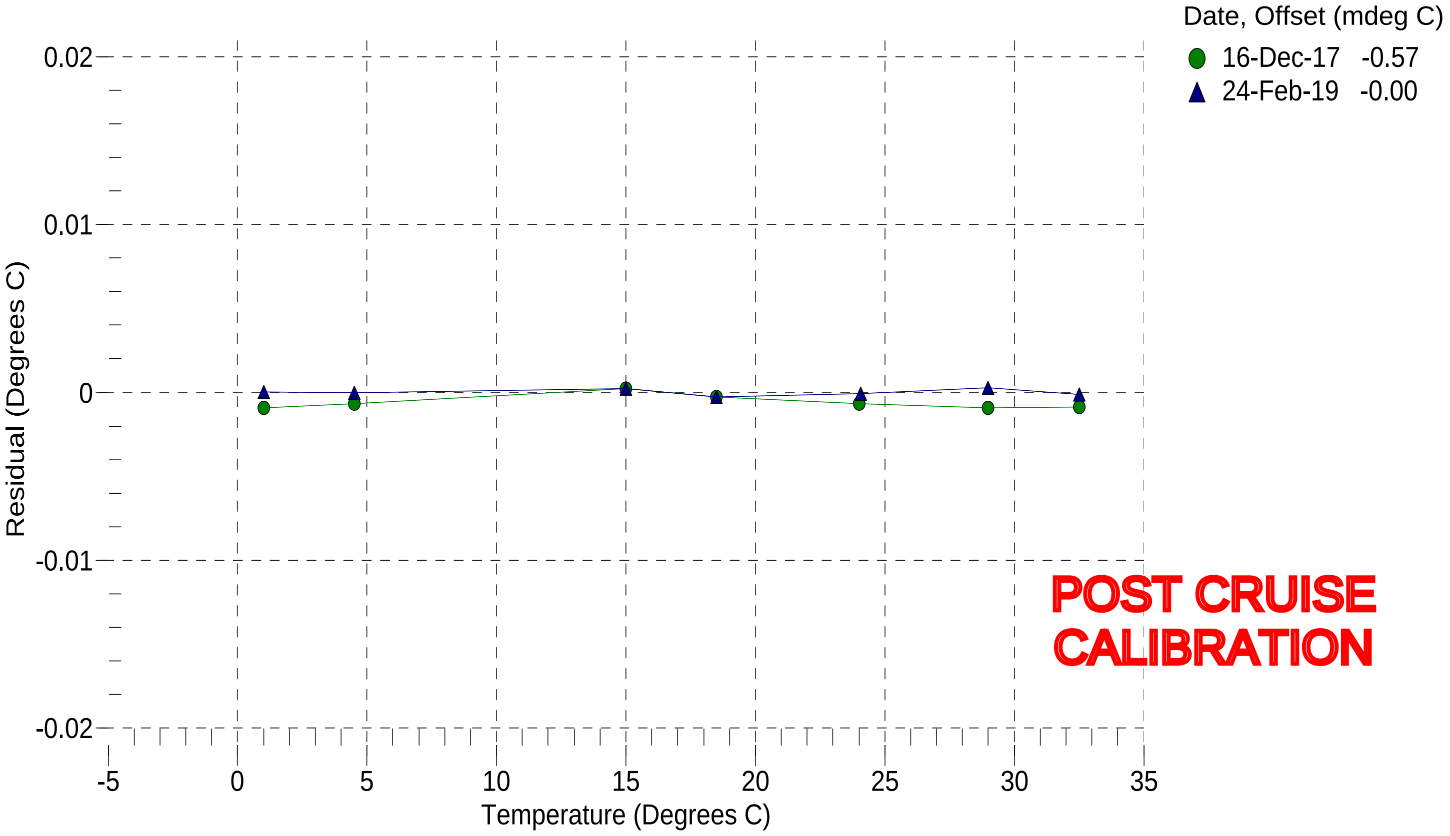
n = Instrument Output (counts)

MV = (n - 524288) / 1.6e+007

R = (MV * 2.900e+009 + 1.024e+008) / (2.048e+004 - MV * 2.0e+005)

Temperature ITS-90 (°C) = $1/\{a0 + a1[\ln(R)] + a2[\ln^2(R)] + a3[\ln^3(R)]\} - 273.15$

Residual (°C) = instrument temperature - bath temperature



POST CRUISE CALIBRATION

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SENSOR SERIAL NUMBER: 6667
CALIBRATION DATE: 22-Feb-19

SBE 19plus V2 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

g = -1.016260e+000
h = 1.326287e-001
i = 3.052794e-004
j = 1.141039e-006

CPcor = -9.5700e-008
CTcor = 3.2500e-006

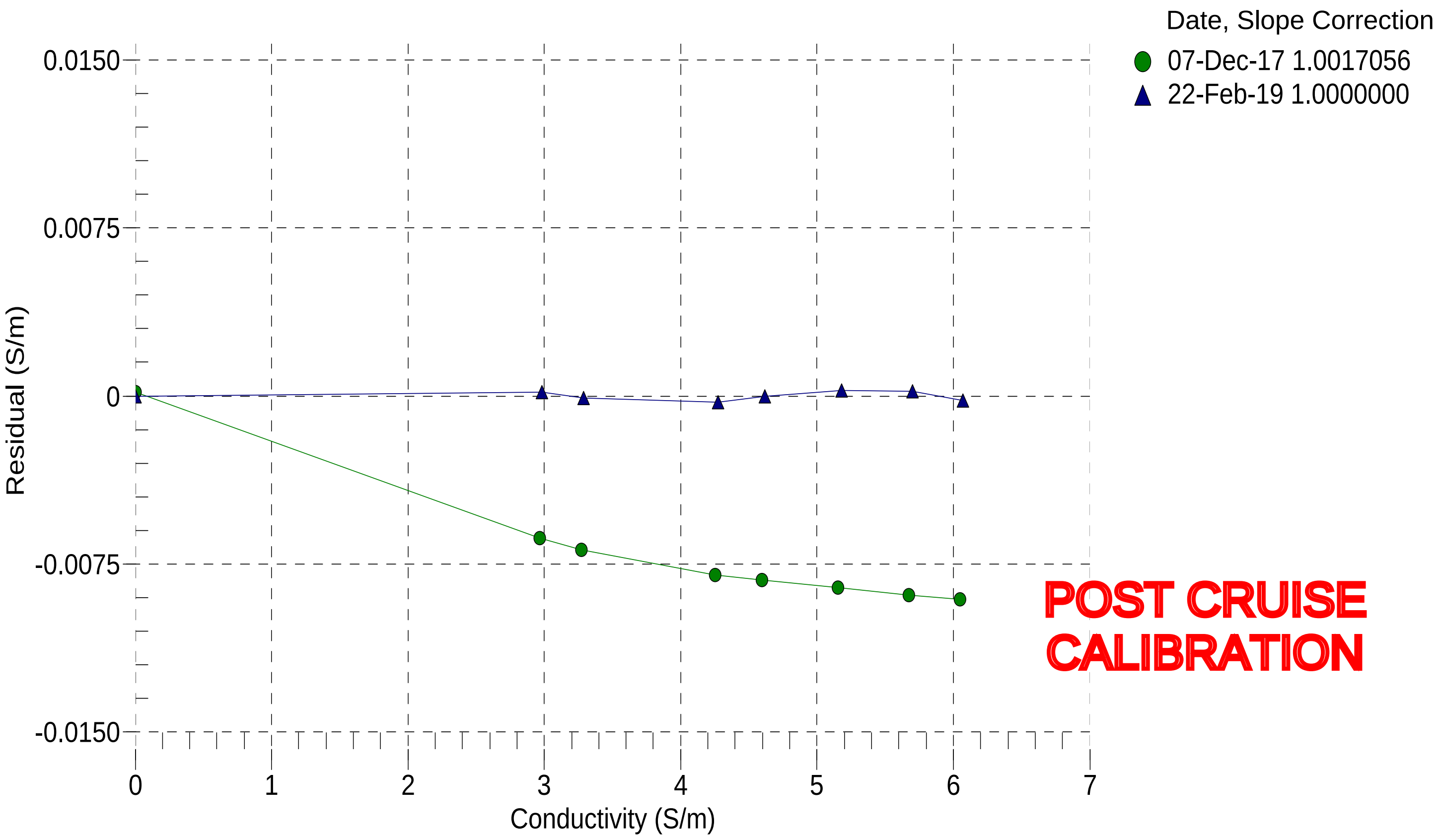
BATH TEMP (° C)	BATH SAL (PSU)	BATH COND (S/m)	INSTRUMENT OUTPUT (Hz)	INSTRUMENT COND (S/m)	RESIDUAL (S/m)
22.0000	0.0000	0.00000	2759.26	0.0000	0.00000
1.0000	34.9019	2.98258	5456.24	2.9828	0.00018
4.5000	34.8817	3.29029	5660.74	3.2902	-0.00010
15.0000	34.8350	4.27366	6269.30	4.2734	-0.00029
18.5000	34.8234	4.61921	6469.48	4.6192	-0.00002
24.0000	34.8096	5.17774	6780.20	5.1780	0.00024
29.0000	34.7941	5.69909	7057.47	5.6993	0.00020
32.5000	34.7808	6.07050	7248.18	6.0703	-0.00022

f = Instrument Output (Hz) / 1000.0

t = temperature (°C);   p = pressure (decibars); δ = CTcor; ε = CPcor;

Conductivity (S/m) = $(g + h * f^2 + i * f^3 + j * f^4) / (1 + \delta * t + \varepsilon * p)$

Residual (Siemens/meter) = instrument conductivity - bath conductivity



POST CRUISE CALIBRATION

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SENSOR SERIAL NUMBER: 6667
CALIBRATION DATE: 28-Apr-19

SBE 19plus V2 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:
g = -1.009894e+000
h = 1.327925e-001
i = -1.312244e-004
j = 2.812224e-005

CPcor = -9.5700e-008
CTcor = 3.2500e-006

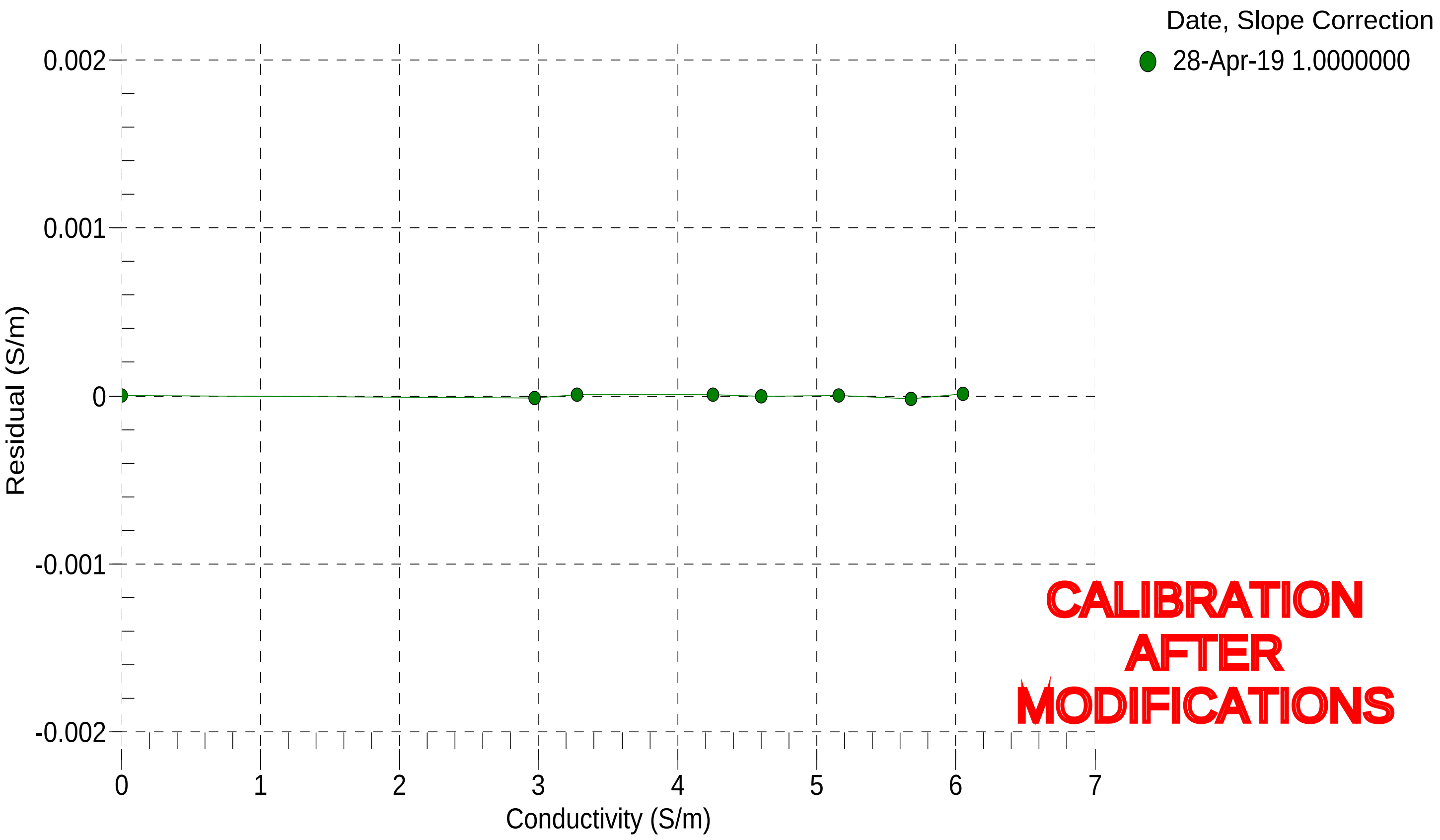
BATH TEMP (° C)	BATH SAL (PSU)	BATH COND (S/m)	INSTRUMENT OUTPUT (Hz)	INSTRUMENT COND (S/m)	RESIDUAL (S/m)
22.0000	0.0000	0.00000	2759.26	0.0000	0.00000
1.0000	34.7401	2.97007	5472.05	2.9701	-0.00001
4.5000	34.7206	3.27658	5678.09	3.2766	0.00001
15.0000	34.6795	4.25660	6290.91	4.2566	0.00001
18.5000	34.6709	4.60116	6492.34	4.6012	-0.00000
23.9999	34.6610	5.15806	6805.03	5.1581	0.00000
29.0000	34.6561	5.67903	7084.70	5.6790	-0.00002
32.5001	34.6531	6.05075	7277.52	6.0508	0.00001

f = Instrument Output (Hz) / 1000.0

t = temperature (°C);   p = pressure (decibars); δ = CTcor; ε = CPcor;

Conductivity (S/m) = $(g + h * f^2 + i * f^3 + j * f^4) / (1 + \delta * t + \varepsilon * p)$

Residual (Siemens/meter) = instrument conductivity - bath conductivity



CALIBRATION AFTER MODIFICATIONS

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SENSOR SERIAL NUMBER: 6667
CALIBRATION DATE: 25-Feb-19

SBE 19plus V2 PRESSURE CALIBRATION DATA
870 psia S/N 3182130

COEFFICIENTS:

```
PA0 =      1.939923e+000
PA1 =      2.629315e-003
PA2 =      2.023969e-011
PTEMPA0 = -6.624494e+001
PTEMPA1 =  5.265316e+001
PTEMPA2 = -5.560835e-001
```

```
PTCA0 =  5.245498e+005
PTCA1 =  5.251437e+001
PTCA2 = -8.594716e-001
PTCB0 =  2.523813e+001
PTCB1 = -9.750000e-004
PTCB2 =  0.000000e+000
```

PRESSURE SPAN CALIBRATION

PRESSURE (PSIA)	INSTRUMENT OUTPUT (counts)	THERMISTOR OUTPUT (volts)	COMPUTED PRESSURE (PSIA)	RESIDUAL (%FSR)
14.51	530067.0	1.7	14.50	-0.00
179.80	592826.0	1.7	179.77	-0.00
359.80	661105.0	1.7	359.72	-0.01
539.81	729334.0	1.7	539.74	-0.01
719.82	797493.0	1.7	719.76	-0.01
869.80	854237.0	1.7	869.78	-0.00
719.82	797550.0	1.7	719.91	0.01
539.84	729399.0	1.7	539.91	0.01
359.82	661167.0	1.7	359.89	0.01
179.81	592848.0	1.7	179.82	0.00
14.50	530069.0	1.7	14.53	0.00

THERMAL CORRECTION

TEMP (°C)	THERMISTOR OUTPUT (volts)	INSTRUMENT OUTPUT (counts)
32.50	1.91	530366.15
29.00	1.85	530355.36
24.00	1.75	530319.59
18.50	1.64	530240.44
15.00	1.57	530161.69
4.50	1.36	529777.98
1.00	1.29	529612.38

TEMPERATURE (°C)	SPAN
-5.00	25.24
35.00	25.20

y = thermistor output (volts)

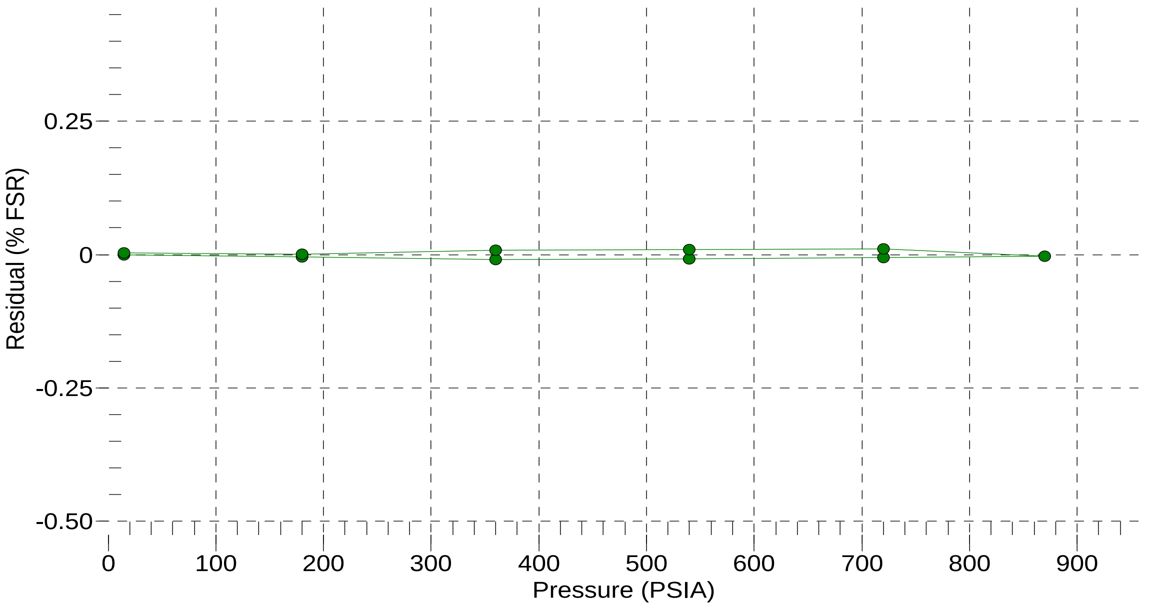
$t = PTEMPA0 + PTEMPA1 * y + PTEMPA2 * y^2$

$x = \text{instrument output} - PTCA0 - PTCA1 * t - PTCA2 * t^2$

$n = x * PTCB0 / (PTCB0 + PTCB1 * t + PTCB2 * t^2)$

$\text{pressure (PSIA)} = PA0 + PA1 * n + PA2 * n^2$

Residual (%FSR) = (computed pressure - true pressure) * 100 / Full Scale Range



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SENSOR SERIAL NUMBER: 6667
CALIBRATION DATE: 22-Feb-19

SBE 19plus V2 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

COEFFICIENTS:
a0 = 1.243217e-003
a1 = 2.607468e-004
a2 = -2.937294e-007
a3 = 1.494587e-007

BATH TEMP (° C)	INSTRUMENT OUTPUT (counts)	INST TEMP (° C)	RESIDUAL (° C)
1.0000	702126.271	1.0000	0.0000
4.5000	626303.085	4.4999	-0.0001
15.0000	435050.085	15.0001	0.0001
18.5000	383015.695	18.5000	-0.0000
24.0000	311966.763	24.0000	-0.0000
29.0000	257608.237	29.0000	-0.0000
32.5000	224675.881	32.5000	0.0000

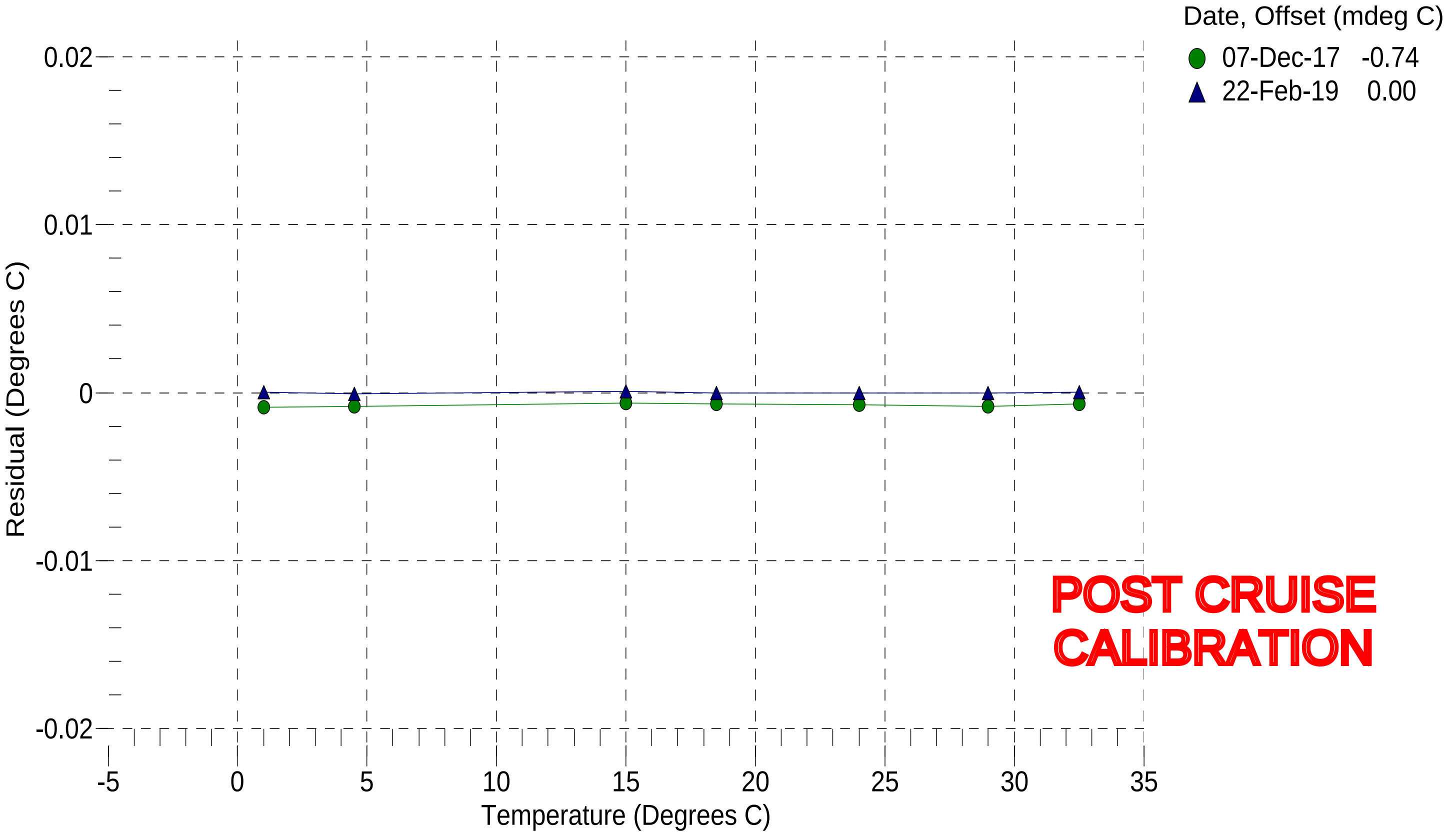
n = Instrument Output (counts)

$MV = (n - 524288) / 1.6e+007$

$R = (MV * 2.900e+009 + 1.024e+008) / (2.048e+004 - MV * 2.0e+005)$

Temperature ITS-90 (°C) $= 1/\{a0 + a1[ln(R)] + a2[ln^2(R)] + a3[ln^3(R)]\} - 273.15$

Residual (°C) = instrument temperature - bath temperature



POST CRUISE
CALIBRATION

Sea-Bird Scientific
13431 NE 20th Street
Bellevue, WA 98005
USA

+1 425-643-9866
seabird@seabird.com
www.seabird.com

SENSOR SERIAL NUMBER: 6667
CALIBRATION DATE: 28-Apr-19

SBE 19plus V2 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

COEFFICIENTS:
a0 = 1.261157e-003
a1 = 2.543000e-004
a2 = 4.776245e-007
a3 = 1.187050e-007

BATH TEMP (° C)	INSTRUMENT OUTPUT (counts)	INST TEMP (° C)	RESIDUAL (° C)
1.0000	702156.525	1.0001	0.0001
4.5000	626331.424	4.4998	-0.0002
15.0000	435068.254	15.0002	0.0002
18.5000	383032.458	18.5001	0.0001
23.9999	311984.424	23.9997	-0.0002
29.0000	257615.119	29.0000	0.0000
32.5001	224677.220	32.5001	0.0000

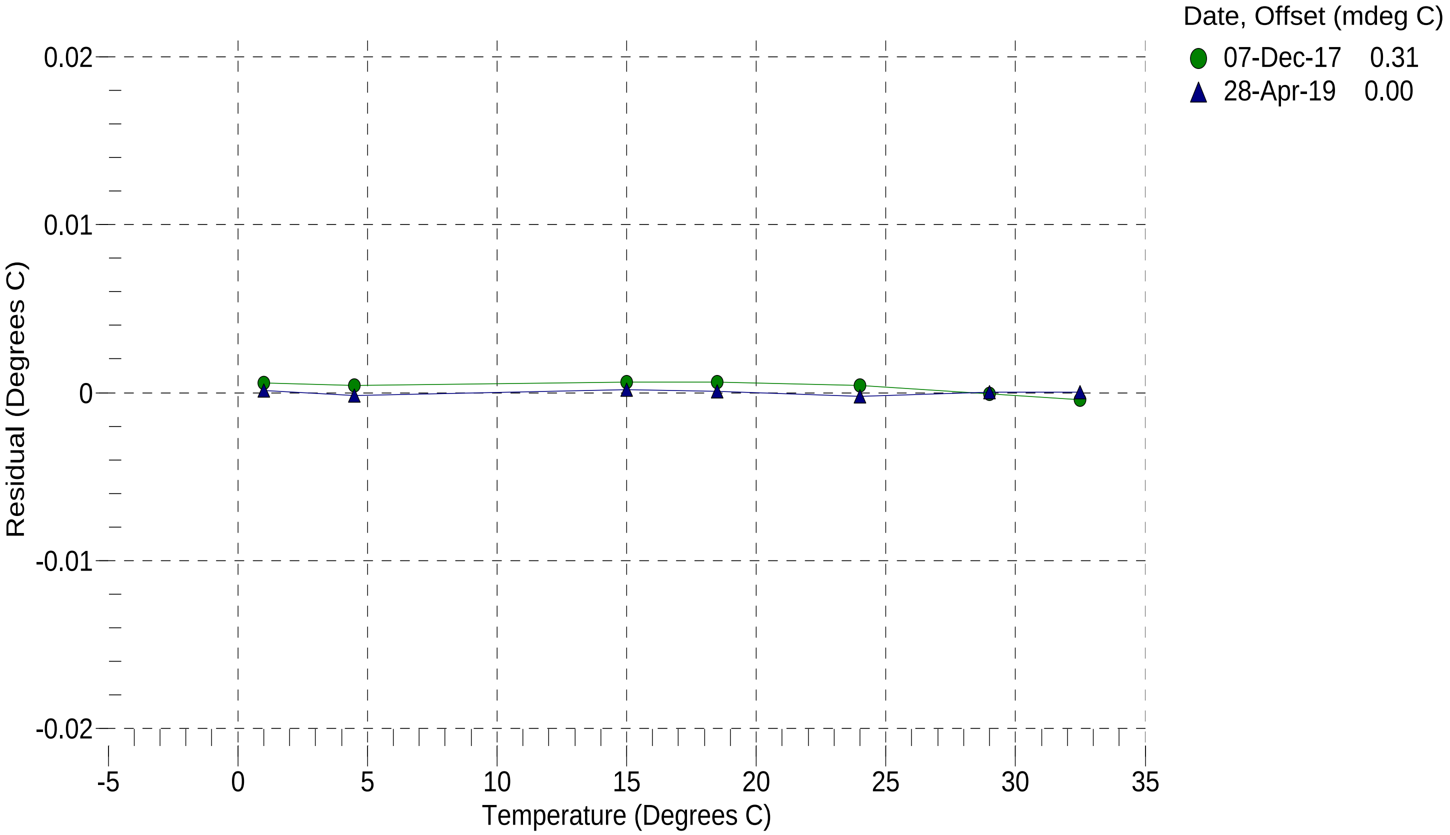
n = Instrument Output (counts)

MV = (n - 524288) / 1.6e+007

R = (MV * 2.900e+009 + 1.024e+008) / (2.048e+004 - MV * 2.0e+005)

Temperature ITS-90 (°C) = $1/\{a0 + a1[ln(R)] + a2[ln^2(R)] + a3[ln^3(R)]\} - 273.15$

Residual (°C) = instrument temperature - bath temperature



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SERVICE REPORT

Service Request **1005504593**
Date 16-MAY-2018
Sales Order 315083155

PRODUCT INFORMATION

Item: 19P.LEGACY
Item Description: (LEGACY) SBE 19Plus (V1/V2) CTD
Serial: 19P33072-4472

Special Notes
Services Requested:
Evaluate/Repair instrumentation.
Perform routine calibration service.

Services Performed:
Perform initial diagnostic evaluation.
Performed pressure calibration.
Performed "POST" cruise calibration.
Replaced the O-rings.
Performed a hydrostatic pressure test.

Item	Item Description	Qty
SERVICE19	Confirm / recertify SBE 19/19plus/19plusV2. Complete External Inspection. Test All Functions and input channel responses. Calibrate C, T, & P. C&P and recal if necessary. Replace O-rings and Hydrostatic pressure test if necessary. Includes typical repairs. (Does not include: Major electronic board replacement. Instruments deemed "Damaged Beyond Repair". Missing/damaged mounts or cables. Upgrades or modifications. Spares or antifoulant replacement.)	1

Unbilled Items

Item	Item Description	Qty

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13431 NE 20th Street
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SENSOR SERIAL NUMBER: 4472
CALIBRATION DATE: 08-May-18

SBE 19plus TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

COEFFICIENTS:
a0 = 1.251795e-003
a1 = 2.612200e-004
a2 = -8.177805e-008
a3 = 1.492391e-007

BATH TEMP (° C)	INSTRUMENT OUTPUT (counts)	INST TEMP (° C)	RESIDUAL (° C)
1.0000	653783.322	1.0000	0.0000
4.5000	581611.339	4.5000	-0.0000
15.0000	401336.373	15.0000	0.0000
18.5000	352678.475	18.5000	0.0000
24.0000	286474.593	23.9999	-0.0001
29.0001	235978.508	29.0002	0.0001
32.5000	205447.661	32.5000	-0.0000

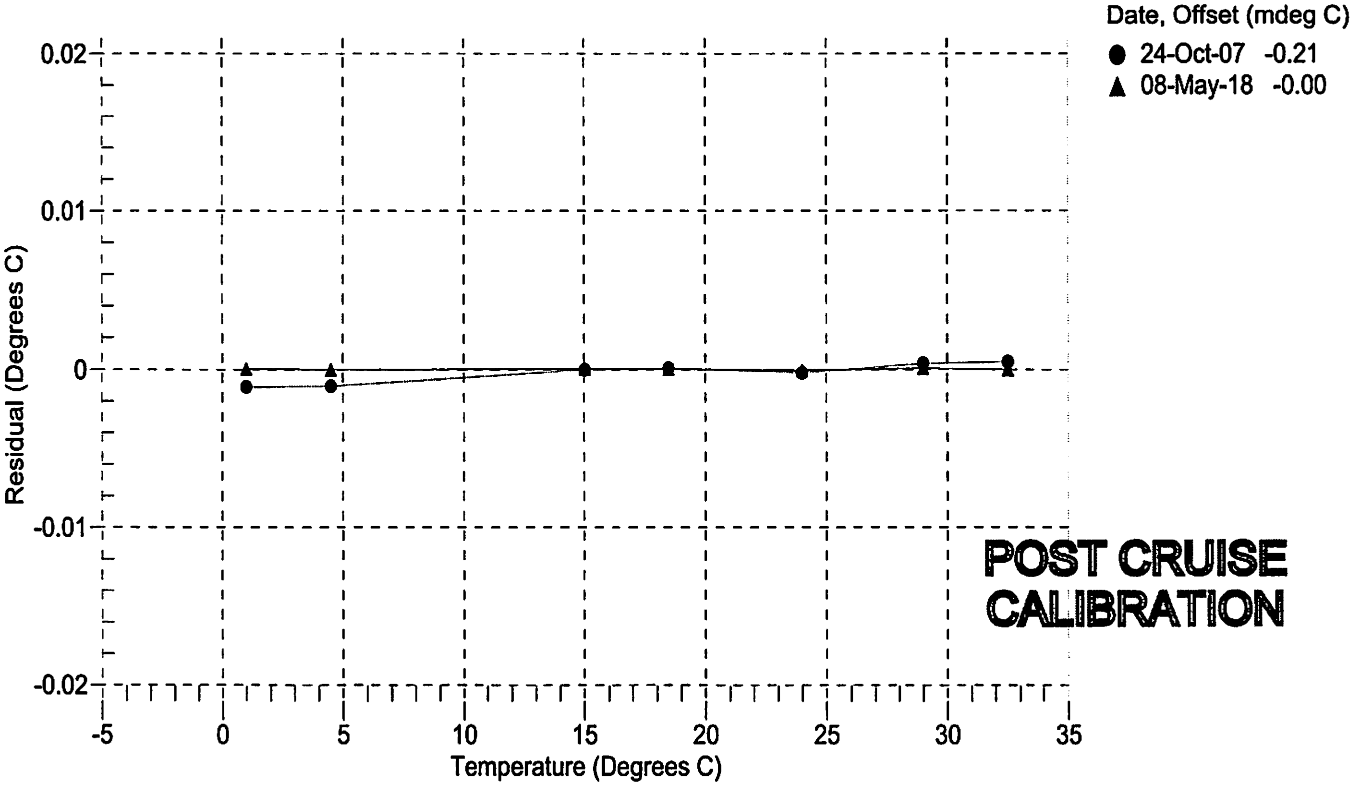
n = Instrument Output (counts)

MV = (n - 524288) / 1.6e+007

R = (MV * 2.900e+009 + 1.024e+008) / (2.048e+004 - MV * 2.0e+005)

Temperature ITS-90 (°C) = $1/\{a0 + a1[ln(R)] + a2[ln^2(R)] + a3[ln^3(R)]\} - 273.15$

Residual (°C) = instrument temperature - bath temperature



POST CRUISE CALIBRATION

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SENSOR SERIAL NUMBER: 4472
CALIBRATION DATE: 08-May-18

SBE 19plus CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

```
g = -1.061023e+000
h =  1.468433e-001
i = -1.082188e-004
j =  2.979217e-005
```

```
CPcor = -9.5700e-008
CTcor =  3.2500e-006
```

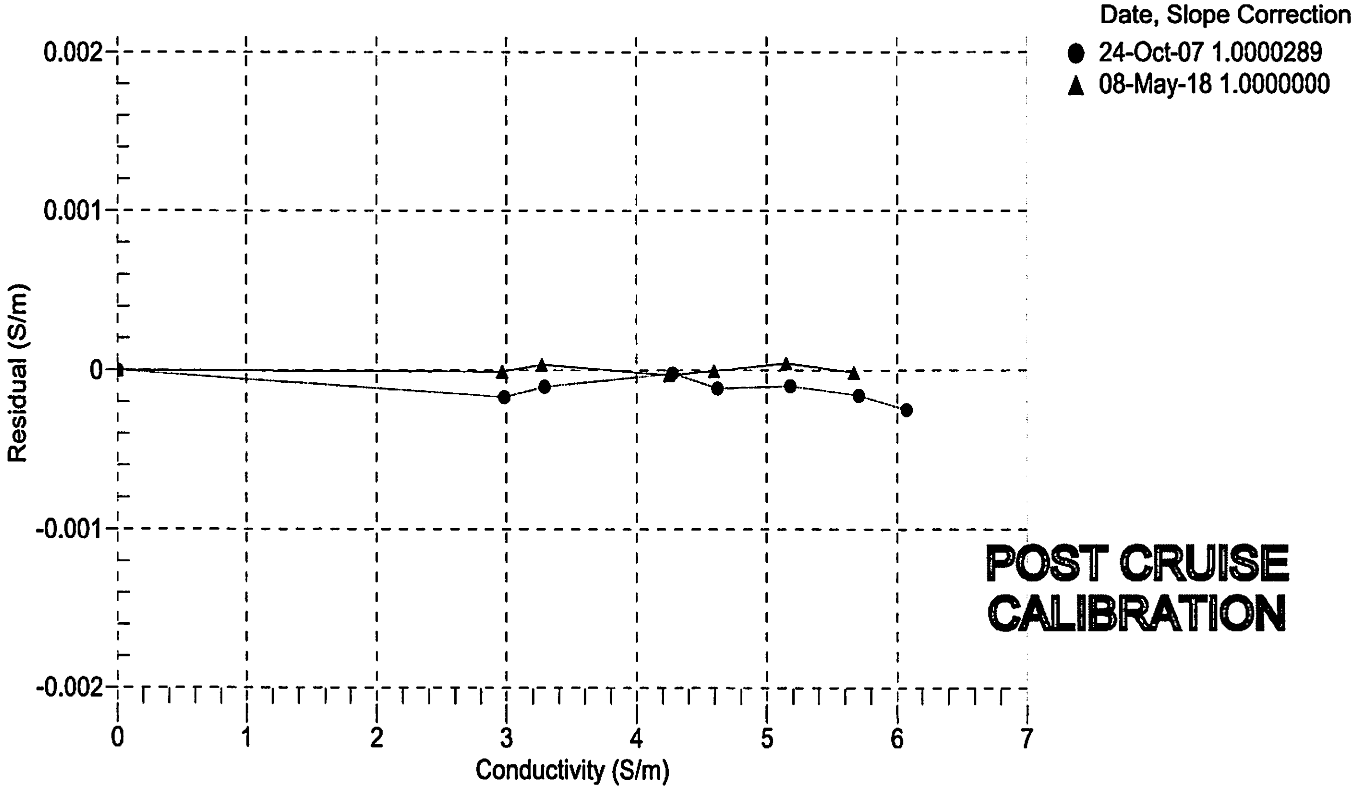
BATH TEMP (° C)	BATH SAL (PSU)	BATH COND (S/m)	INSTRUMENT OUTPUT (Hz)	INSTRUMENT COND (S/m)	RESIDUAL (S/m)
22.0000	0.0000	0.00000	2688.73	0.0000	0.00000
1.0000	34.6781	2.96528	5231.87	2.9653	-0.00001
4.5000	34.6551	3.27101	5426.18	3.2710	0.00003
15.0000	34.6058	4.24851	6004.57	4.2485	-0.00003
18.5000	34.5922	4.59184	6194.69	4.5918	-0.00001
24.0000	34.5773	5.14699	6490.07	5.1470	0.00004
29.0001	34.5671	5.66609	6754.25	5.6661	-0.00002
32.5000	34.5571	6.03588	6936.09	6.0357	-0.00017

f = Instrument Output (Hz) / 1000.0

t = temperature (°C); p = pressure (decibars); δ = CTcor; ε = CPcor;

Conductivity (S/m) = $(g + h * f^2 + i * f^3 + j * f^4) / (1 + \delta * t + \varepsilon * p)$

Residual (Siemens/meter) = instrument conductivity - bath conductivity



POST CRUISE CALIBRATION

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SENSOR SERIAL NUMBER: 4472
CALIBRATION DATE: 01-May-18

SBE 19plus PRESSURE CALIBRATION DATA
508 psia S/N 2790

COEFFICIENTS:

PA0 = 1.201471e-001
PA1 = 1.556803e-003
PA2 = 7.136402e-012
PTEMPA0 = -7.740514e+001
PTEMPA1 = 4.835624e+001
PTEMPA2 = -2.484909e-001

PTCA0 = 5.247401e+005
PTCA1 = 6.056032e+000
PTCA2 = -1.147860e-001
PTCB0 = 2.461350e+001
PTCB1 = 1.500000e-003
PTCB2 = 0.000000e+000

PRESSURE SPAN CALIBRATION

PRESSURE (PSIA)	INSTRUMENT OUTPUT (counts)	THERMISTOR OUTPUT (volts)	COMPUTED PRESSURE (PSIA)	RESIDUAL (%FSR)
14.65	534160.0	2.1	14.64	-0.00
104.91	592200.0	2.1	104.91	-0.00
204.91	656444.0	2.1	204.88	-0.01
304.91	720679.0	2.1	304.90	-0.00
404.91	784868.0	2.1	404.90	-0.00
504.91	849020.0	2.1	504.90	-0.00
404.91	784888.0	2.1	404.93	0.00
304.92	720701.0	2.1	304.93	0.00
204.92	656477.0	2.1	204.93	0.00
104.93	592219.0	2.1	104.94	0.00
14.65	534166.0	2.1	14.65	0.00

THERMAL CORRECTION

TEMP (°C)	THERMISTOR OUTPUT (volts)	INSTRUMENT OUTPUT (counts)
32.50	2.30	534425.59
29.00	2.23	534426.10
24.00	2.12	534424.74
18.50	2.00	534422.55
15.00	1.93	534414.65
4.50	1.71	534372.76
1.00	1.64	534354.06

TEMPERATURE (°C)	SPAN
-5.00	24.61
35.00	24.67

y = thermistor output (volts)

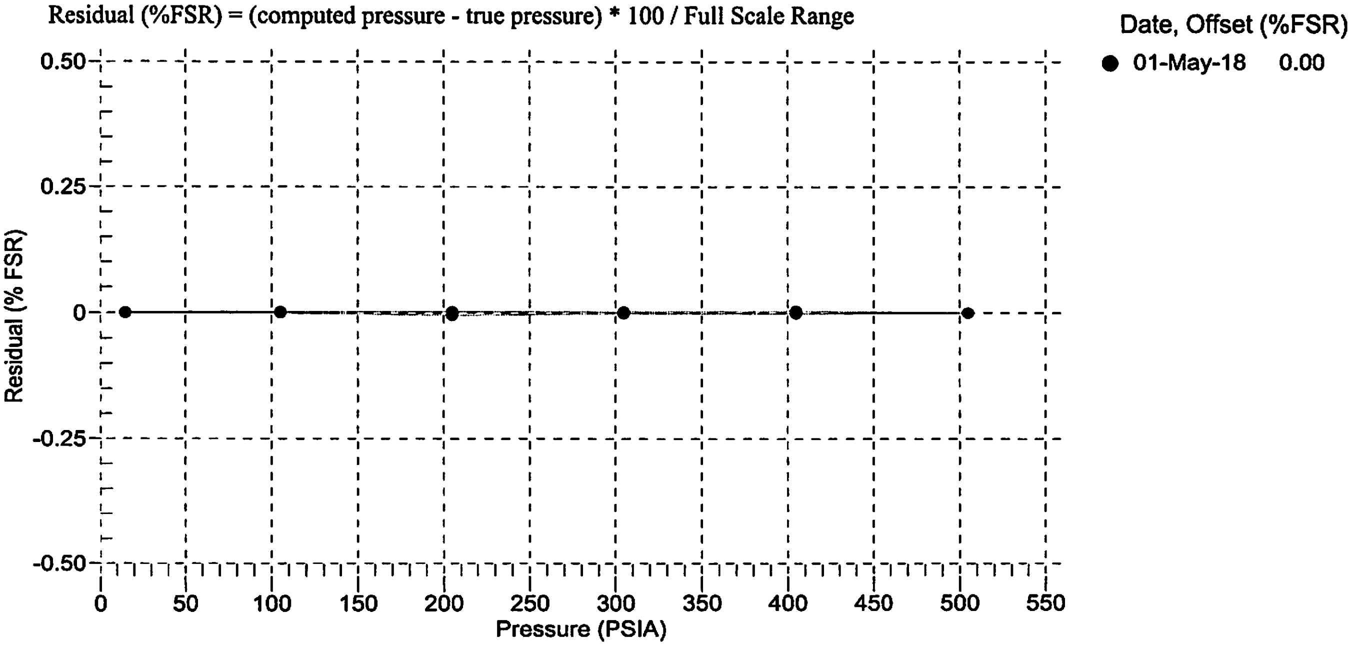
$t = PTEMPA0 + PTEMPA1 * y + PTEMPA2 * y^2$

$x = \text{instrument output} - PTCA0 - PTCA1 * t - PTCA2 * t^2$

$n = x * PTCB0 / (PTCB0 + PTCB1 * t + PTCB2 * t^2)$

$\text{pressure (PSIA)} = PA0 + PA1 * n + PA2 * n^2$

Residual (%FSR) = (computed pressure - true pressure) * 100 / Full Scale Range



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SERVICE REPORT

Service Request	**1005504593**
Date	16-MAY-2018
Sales Order	315083155

PRODUCT INFORMATION

Item: 05M.LEGACY
Item Description: (LEGACY) SBE 05M Submersible Pump
Serial: 050616

Special Notes
Services Requested:
Evaluate/Repair Instrumentation.

Services Performed:
Perform initial diagnostic evaluation.

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SERVICE REPORT

Service Request	**1005504593**
Date	16-MAY-2018
Sales Order	315083155

CUSTOMER INFORMATION

Name: ATLANTIC MARINE CENTER
Account : 40280367
THANH LOI
THANH.LOI@NOAA.GOV
757-441-6814

PO Number:
EA-133M-16-CQ-0039_D0054

Bill To Address
439 WEST YORK STREET;NOAA/Marine Operations Center - Atlantic;
NORFOLK,VA,23510,US

Ship To Address
AN700073;MOAXI;439 WEST YORK STREET;

NORFOLK,VA,23510,US

PRODUCT INFORMATION

Item: 19P.LEGACY
Item Description: (LEGACY) SBE 19Plus (V1/V2) CTD
Serial: 19P36399-4630 CD0001478891

Special Notes
Services Requested:
Evaluate/Repair instrumentation.
Perform routine calibration service.

Problems Found:
The 4-pin and 2-pin connectors were found to have corrosion damage.
The magnet switch was found to have corrosion damage.

Services Performed:
Perform initial diagnostic evaluation.
Replaced the lithium back-up battery(s).
Replaced the 4-pin and 2-pin connectors.
Replaced the switch magnet.
Replaced the O-rings.
Performed a hydrostatic pressure test.
Performed pressure calibration.
Performed "POST" cruise calibration.

Item	Item Description	Qty
SERVICE19	Confirm / recertify SBE 19/19plus/19plusV2. Complete External Inspection. Test All Functions and input channel responses. Calibrate C, T, & P. C&P and recal if necessary. Replace O-rings and Hydrostatic pressure test if necessary. Includes typical repairs. (Does not include: Major electronic board replacement. Instruments deemed "Damaged Beyond Repair". Missing/damaged mounts or cables. Upgrades or modifications. Spares or antifoulant replacement.)	1

SERVICE REPORT

Service Request **1005504593**
Date 16-MAY-2018
Sales Order 315083155

Unbilled Items

Item	Item Description	Qty
17654	Bulkhead connector, 4-pin Standard, XSG-4-BCL-HP-SS	1
17652	Bulkhead connector, 2-pin Standard, XSG-2-BCL-HP-SS	1
231788.1	SEACAT/PROFILER MAGNET HOLDER W/MAGNET ASSY	1
22009	Lithium back-up battery (BR-2/3A-T2SP)	3

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SENSOR SERIAL NUMBER: 4630
CALIBRATION DATE: 11-May-18

SBE 19plus TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

COEFFICIENTS:
a0 = 1.157076e-003
a1 = 2.765465e-004
a2 = -1.254191e-006
a3 = 1.927530e-007

BATH TEMP (° C)	INSTRUMENT OUTPUT (counts)	INST TEMP (° C)	RESIDUAL (° C)
1.0000	687471.797	1.0001	0.0001
4.5000	614607.017	4.4999	-0.0001
15.0000	430623.237	15.0002	0.0002
18.5000	380421.576	18.4999	-0.0001
24.0000	311673.797	24.0000	0.0000
28.9999	258869.797	28.9998	-0.0001
32.5000	226761.525	32.5001	0.0001

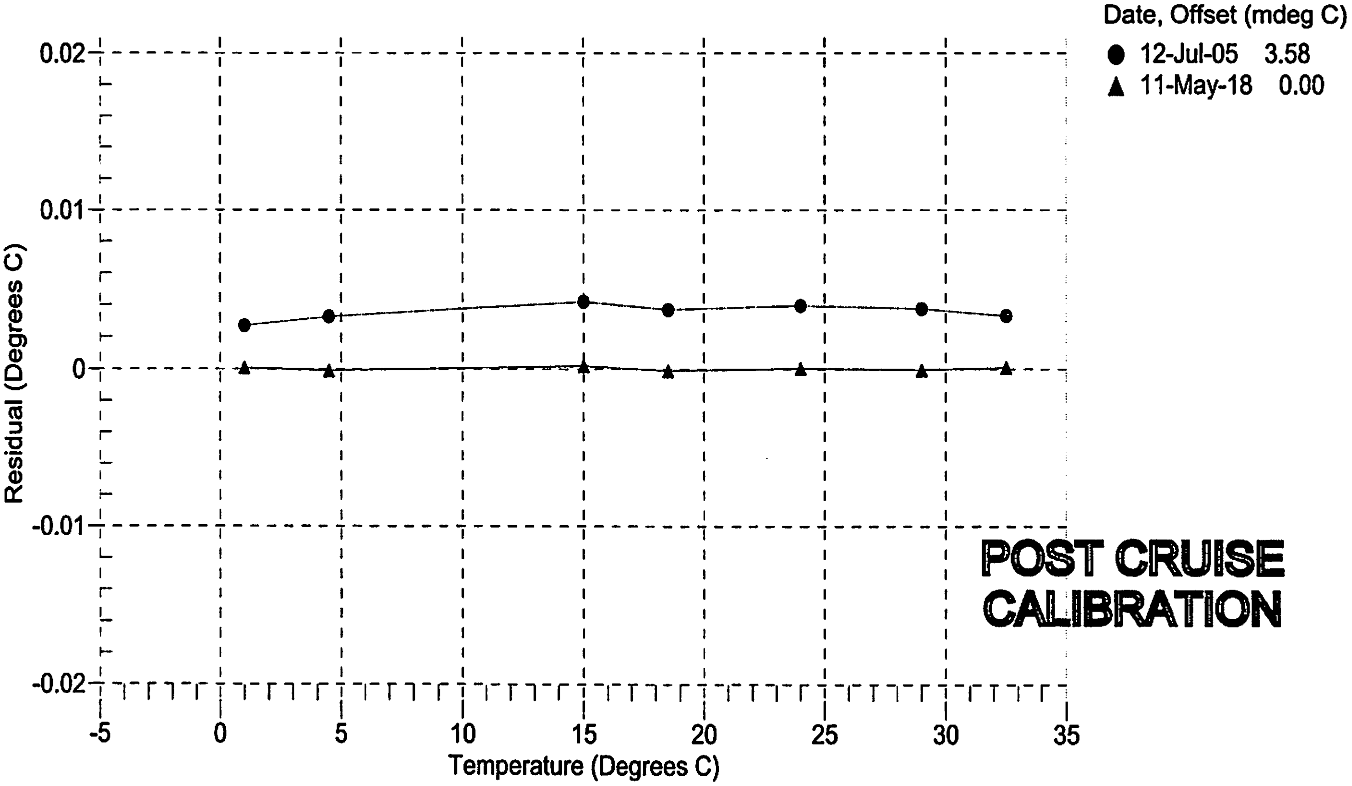
n = Instrument Output (counts)

MV = (n - 524288) / 1.6e+007

R = (MV * 2.900e+009 + 1.024e+008) / (2.048e+004 - MV * 2.0e+005)

Temperature ITS-90 (°C) = $1/\{a0 + a1[ln(R)] + a2[ln^2(R)] + a3[ln^3(R)]\} - 273.15$

Residual (°C) = instrument temperature - bath temperature



POST CRUISE CALIBRATION

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SENSOR SERIAL NUMBER: 4630
CALIBRATION DATE: 11-May-18

SBE 19plus CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

g = -1.041672e+000
h = 1.304723e-001
i = -2.211569e-004
j = 3.292292e-005

CPcor = -9.5700e-008
CTcor = 3.2500e-006

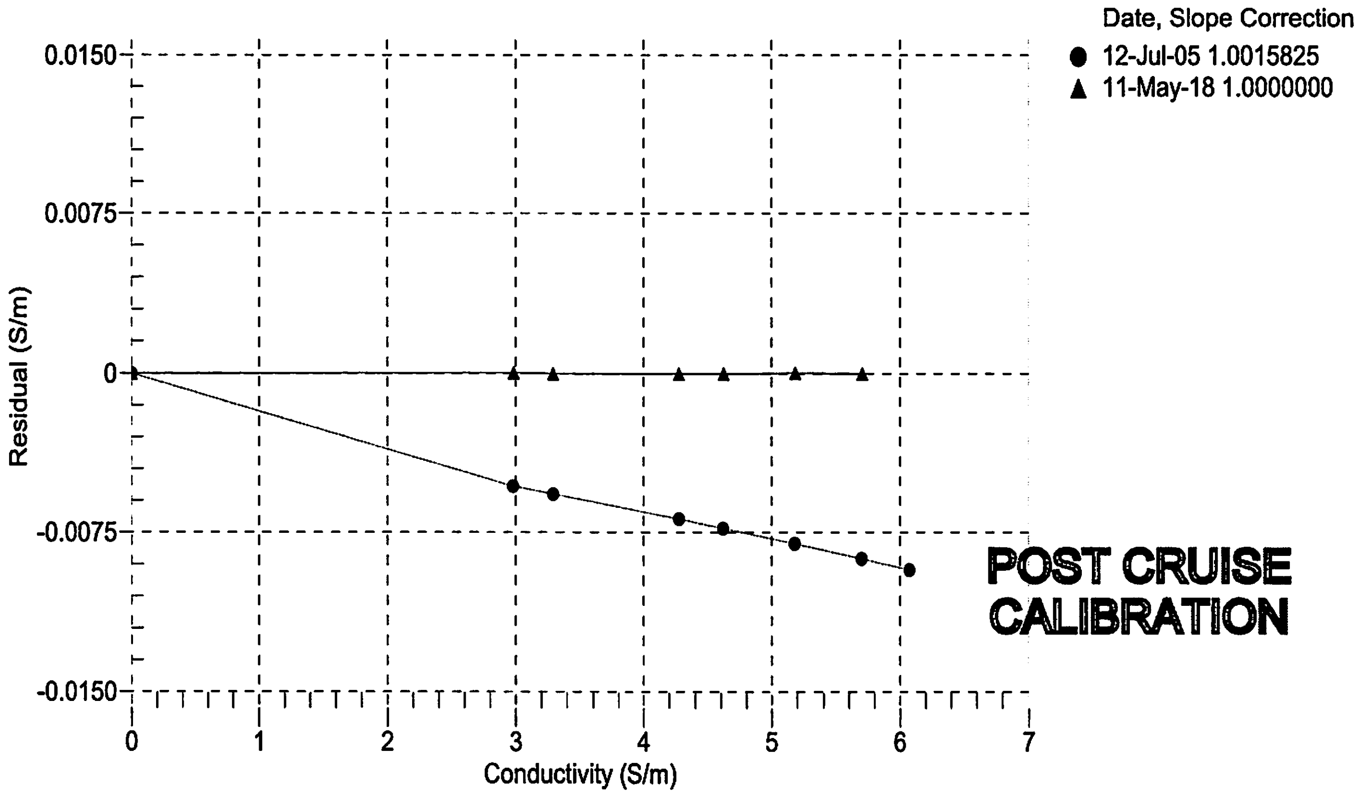
BATH TEMP (° C)	BATH SAL (PSU)	BATH COND (S/m)	INSTRUMENT OUTPUT (Hz)	INSTRUMENT COND (S/m)	RESIDUAL (S/m)
22.0000	0.0000	0.00000	2829.50	0.0000	0.00000
1.0000	34.9105	2.98325	5558.71	2.9833	0.00002
4.5000	34.8909	3.29107	5766.66	3.2911	-0.00002
15.0000	34.8483	4.27512	6385.43	4.2751	-0.00001
18.5000	34.8391	4.62107	6588.87	4.6211	-0.00000
24.0000	34.8289	5.18029	6904.76	5.1803	0.00003
28.9999	34.8225	5.70321	7187.20	5.7032	-0.00001
32.5000	34.8176	6.07619	7381.82	6.0761	-0.00010

f = Instrument Output (Hz) / 1000.0

t = temperature (°C); p = pressure (decibars); δ = CTcor; ε = CPcor;

Conductivity (S/m) = $(g + h * f^2 + i * f^3 + j * f^4) / (1 + \delta * t + \varepsilon * p)$

Residual (Siemens/meter) = instrument conductivity - bath conductivity



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SENSOR SERIAL NUMBER: 4630
CALIBRATION DATE: 07-May-18

SBE 19plus PRESSURE CALIBRATION DATA
508 psia S/N 5498

COEFFICIENTS:

PA0 = 3.948192e-002
PA1 = 1.555691e-003
PA2 = 7.301987e-012
PTEMPA0 = -7.769528e+001
PTEMPA1 = 4.870907e+001
PTEMPA2 = -2.457836e-001

PTCA0 = 5.244174e+005
PTCA1 = 4.129098e+000
PTCA2 = -1.353582e-001
PTCB0 = 2.500438e+001
PTCB1 = -5.250000e-004
PTCB2 = 0.000000e+000

PRESSURE SPAN CALIBRATION

PRESSURE (PSIA)	INSTRUMENT OUTPUT (counts)	THERMISTOR OUTPUT (volts)	COMPUTED PRESSURE (PSIA)	RESIDUAL (%FSR)
14.72	533869.0	2.1	14.71	-0.00
104.98	591842.0	2.1	104.98	-0.00
204.98	656021.0	2.1	204.96	-0.00
304.98	720174.0	2.1	304.96	-0.00
404.98	784300.0	2.1	404.99	0.00
504.99	848373.0	2.1	504.98	-0.00
404.99	784311.0	2.1	405.00	0.00
304.99	720198.0	2.1	305.00	0.00
204.99	656048.0	2.1	205.00	0.00
104.99	591862.0	2.1	105.01	0.00
14.72	533875.0	2.1	14.72	0.00

THERMAL CORRECTION

TEMP (°C)	THERMISTOR OUTPUT (volts)	INSTRUMENT OUTPUT (counts)
32.50	2.29	533997.47
29.00	2.21	534016.77
24.00	2.11	534035.67
18.50	2.00	534035.75
15.00	1.92	534039.30
4.50	1.70	534024.46
1.00	1.63	534014.23

TEMPERATURE (°C)	SPAN
-5.00	25.01
35.00	24.99

y = thermistor output (volts)

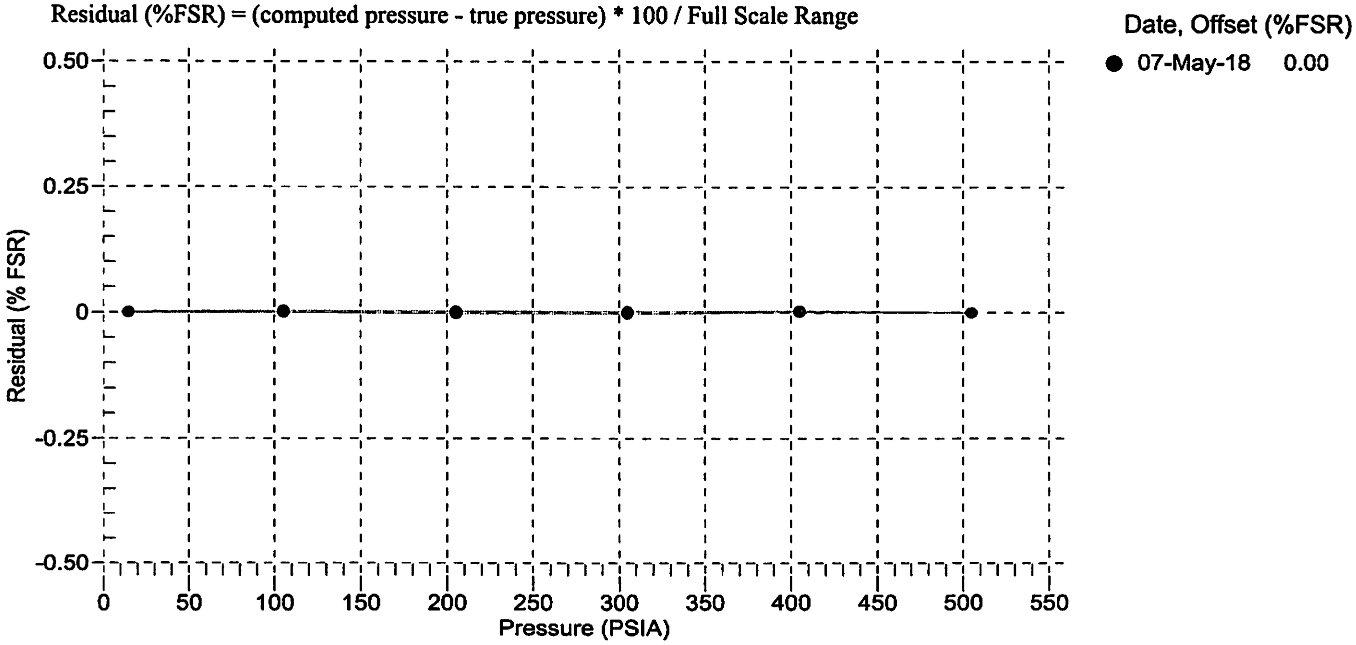
$t = PTEMPA0 + PTEMPA1 * y + PTEMPA2 * y^2$

$x = \text{instrument output} - PTCA0 - PTCA1 * t - PTCA2 * t^2$

$n = x * PTCB0 / (PTCB0 + PTCB1 * t + PTCB2 * t^2)$

$\text{pressure (PSIA)} = PA0 + PA1 * n + PA2 * n^2$

Residual (%FSR) = (computed pressure - true pressure) * 100 / Full Scale Range



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SERVICE REPORT

Service Request **1005504593**
Date 16-MAY-2018
Sales Order 315083155

PRODUCT INFORMATION

Item: 05M.LEGACY
Item Description: (LEGACY) SBE 05M Submersible Pump
Serial: 050662

Special Notes
Services Requested:
Evaluate/Repair Instrumentation.

Services Performed:
Perform initial diagnostic evaluation.

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SERVICE REPORT

Service Request 1005506708
Date 17-MAY-2019
Sales Order 315443269

CUSTOMER INFORMATION

Name: ATLANTIC MARINE CENTER
Account : 40280367
RICHARD CONWAY
chiefet.thomas.jefferson@noaa.gov
7576470187

PO Number:
IDIQ contract

Bill To Address
439 WEST YORK STREET;NOAA/Marine Operations Center - Atlantic;
NORFOLK,VA,23510,US

Ship To Address
AN700073;MOAXI;439 WEST YORK STREET;

NORFOLK,VA,23510,US

PRODUCT INFORMATION

Item: 19P.LEGACY
Item Description: (LEGACY) SBE 19Plus (V1/V2) CTD
Serial: 19P60744-6667

Special Notes
Services Requested:
Evaluate/Repair Instrumentation.
Perform Routine Calibration Service.
Replace the instruments "O"-rings.
Perform hydrostatic pressure test.

Problems Found:
The Pump/Data I/O cable was found to have an intermittent open.
The conductivity cell was found to have positive drift.
The mother board was found to have failed.

Services Performed:
Perform initial diagnostic evaluation.
Replaced the conductivity cell.
Replaced the motherboard.
Replaced the O-rings.
Performed a hydrostatic pressure test.
Performed pressure calibration.
Performed a "Final" Calibration.
Replaced the Pump/ Data I/O cable.

Item	Item Description	Qty
17797	Y-cable, Pump-Data I/O, Standard connectors (DN 31551)	1
SERVICE19	Confirm / recertify SBE 19/19plus/19plusV2. Complete External Inspection. Test All Functions and input channel responses. Calibrate C, T, & P. C&P and recal if necessary. Replace O-rings and Hydrostatic pressure test if necessary. Includes typical repairs. (Does not include: Major electronic board replacement. Instruments deemed "Damaged Beyond Repair". Missing/damaged mounts or cables. Upgrades or modifications. Spares or antifoulant replacement.)	1

Unbilled Items

Item	Item Description	Qty
801139	MODULAR MICROCAT COND. CELL TRAY ASSEMBLY	1
801139	MODULAR MICROCAT COND. CELL TRAY ASSEMBLY	1
41599	SEACAT PLUS SPLIT MOTHERBOARD, T&C /41599	1
22009	Lithium back-up battery (BR-2/3A-T2SP)	3

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SENSOR SERIAL NUMBER: 6667
CALIBRATION DATE: 28-Apr-19

SBE 19plus V2 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

COEFFICIENTS:
a0 = 1.261157e-003
a1 = 2.543000e-004
a2 = 4.776245e-007
a3 = 1.187050e-007

BATH TEMP (° C)	INSTRUMENT OUTPUT (counts)	INST TEMP (° C)	RESIDUAL (° C)
1.0000	702156.525	1.0001	0.0001
4.5000	626331.424	4.4998	-0.0002
15.0000	435068.254	15.0002	0.0002
18.5000	383032.458	18.5001	0.0001
23.9999	311984.424	23.9997	-0.0002
29.0000	257615.119	29.0000	0.0000
32.5001	224677.220	32.5001	0.0000

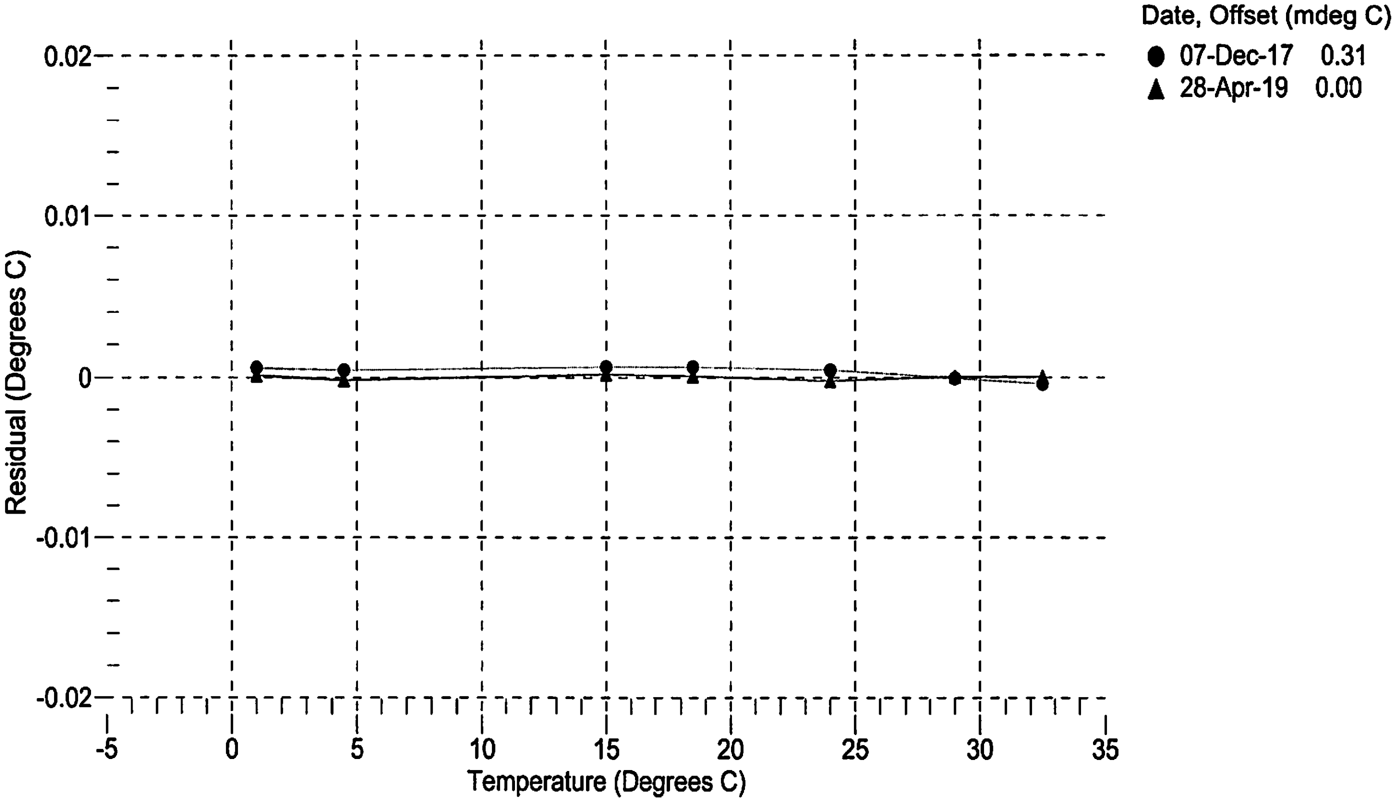
n = Instrument Output (counts)

$MV = (n - 524288) / 1.6e{+}007$

$R = (MV * 2.900e{+}009 + 1.024e{+}008) / (2.048e{+}004 - MV * 2.0e{+}005)$

Temperature ITS-90 (°C) = $1/\{a0 + a1[\mathit{ln}(R)] + a2[\mathit{ln}^2(R)] + a3[\mathit{ln}^3(R)]\} - 273.15$

Residual (°C) = instrument temperature - bath temperature



SEA·BIRD
SCIENTIFIC

Sea-Bird Scientific
13431 NE 20th Street
Bellevue, WA 98005
USA

+1 425-643-9866
seabird@seabird.com
www.seabird.com

SENSOR SERIAL NUMBER: 6667
CALIBRATION DATE: 28-Apr-19

SBE 19plus V2 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

g = -1.009894e+000
h = 1.327925e-001
i = -1.312244e-004
j = 2.812224e-005

CPcor = -9.5700e-008
CTcor = 3.2500e-006

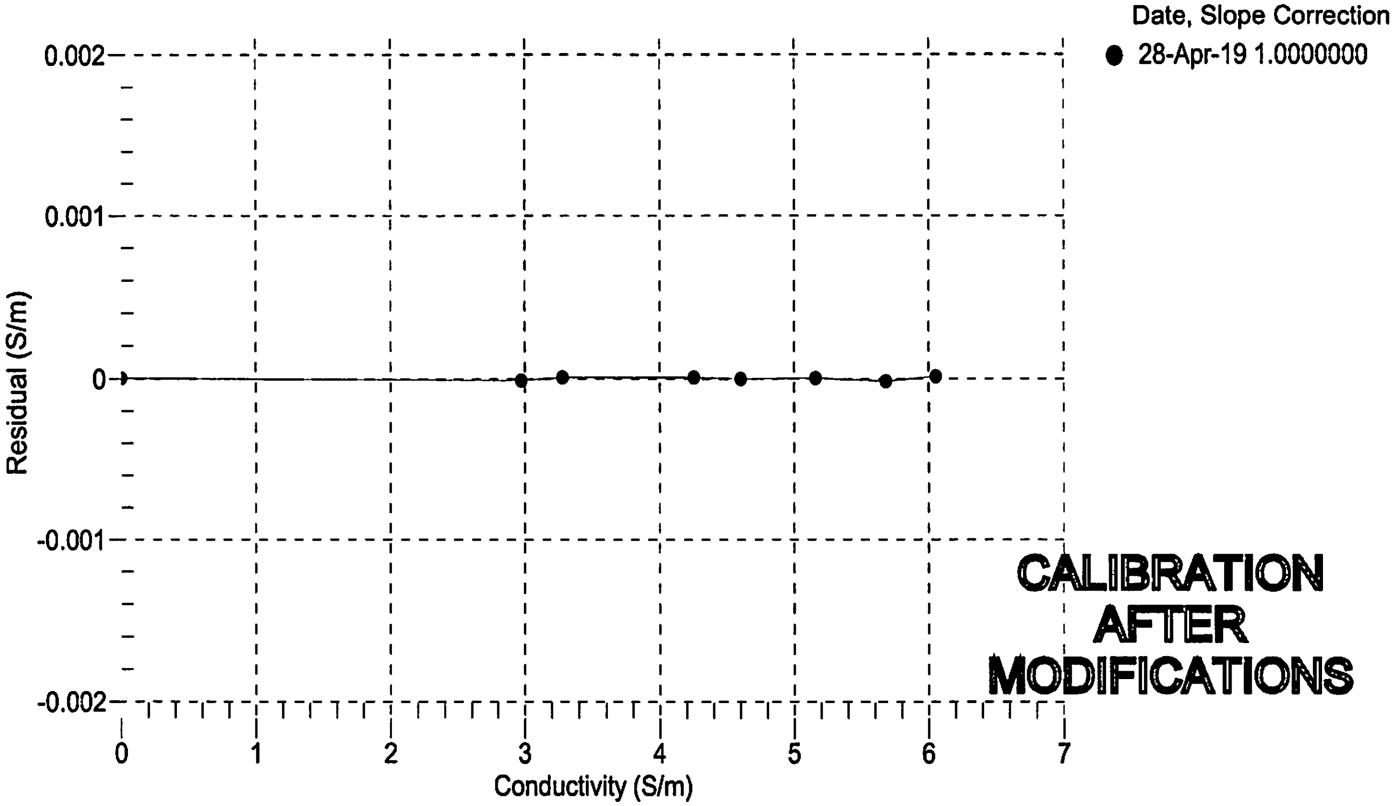
BATH TEMP (° C)	BATH SAL (PSU)	BATH COND (S/m)	INSTRUMENT OUTPUT (Hz)	INSTRUMENT COND (S/m)	RESIDUAL (S/m)
22.0000	0.0000	0.00000	2759.26	0.0000	0.00000
1.0000	34.7401	2.97007	5472.05	2.9701	-0.00001
4.5000	34.7206	3.27658	5678.09	3.2766	0.00001
15.0000	34.6795	4.25660	6290.91	4.2566	0.00001
18.5000	34.6709	4.60116	6492.34	4.6012	-0.00000
23.9999	34.6610	5.15806	6805.03	5.1581	0.00000
29.0000	34.6561	5.67903	7084.70	5.6790	-0.00002
32.5001	34.6531	6.05075	7277.52	6.0508	0.00001

f = Instrument Output (Hz) / 1000.0

t = temperature (°C); p = pressure (decibars); δ = CTcor; ε = CPcor;

Conductivity (S/m) = $(g + h * f^2 + i * f^3 + j * f^4) / (1 + \delta * t + \varepsilon * p)$

Residual (Siemens/meter) = instrument conductivity - bath conductivity



CALIBRATION
AFTER
MODIFICATIONS

SEA·BIRD SCIENTIFIC

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13431 NE 20th Street
Bellevue, WA 98005
USA

+1 425-643-9866
seabird@seabird.com
www.seabird.com

SENSOR SERIAL NUMBER: 6667
CALIBRATION DATE: 25-Feb-19

SBE 19plus V2 PRESSURE CALIBRATION DATA
870 psia S/N 3182130

COEFFICIENTS:

PA0 = 1.939923e+000
PA1 = 2.629315e-003
PA2 = 2.023969e-011
PTEMPA0 = -6.624494e+001
PTEMPA1 = 5.265316e+001
PTEMPA2 = -5.560835e-001

PTCA0 = 5.245498e+005
PTCA1 = 5.251437e+001
PTCA2 = -8.594716e-001
PTCB0 = 2.523813e+001
PTCB1 = -9.750000e-004
PTCB2 = 0.000000e+000

PRESSURE SPAN CALIBRATION

PRESSURE (PSIA)	INSTRUMENT OUTPUT (counts)	THERMISTOR OUTPUT (volts)	COMPUTED PRESSURE (PSIA)	RESIDUAL (%FSR)
14.51	530067.0	1.7	14.50	-0.00
179.80	592826.0	1.7	179.77	-0.00
359.80	661105.0	1.7	359.72	-0.01
539.81	729334.0	1.7	539.74	-0.01
719.82	797493.0	1.7	719.76	-0.01
869.80	854237.0	1.7	869.78	-0.00
719.82	797550.0	1.7	719.91	0.01
539.84	729399.0	1.7	539.91	0.01
359.82	661167.0	1.7	359.89	0.01
179.81	592848.0	1.7	179.82	0.00
14.50	530069.0	1.7	14.53	0.00

THERMAL CORRECTION

TEMP (°C)	THERMISTOR OUTPUT (volts)	INSTRUMENT OUTPUT (counts)
32.50	1.91	530366.15
29.00	1.85	530355.36
24.00	1.75	530319.59
18.50	1.64	530240.44
15.00	1.57	530161.69
4.50	1.36	529777.98
1.00	1.29	529612.38

TEMPERATURE (°C)	SPAN
-5.00	25.24
35.00	25.20

y = thermistor output (volts)

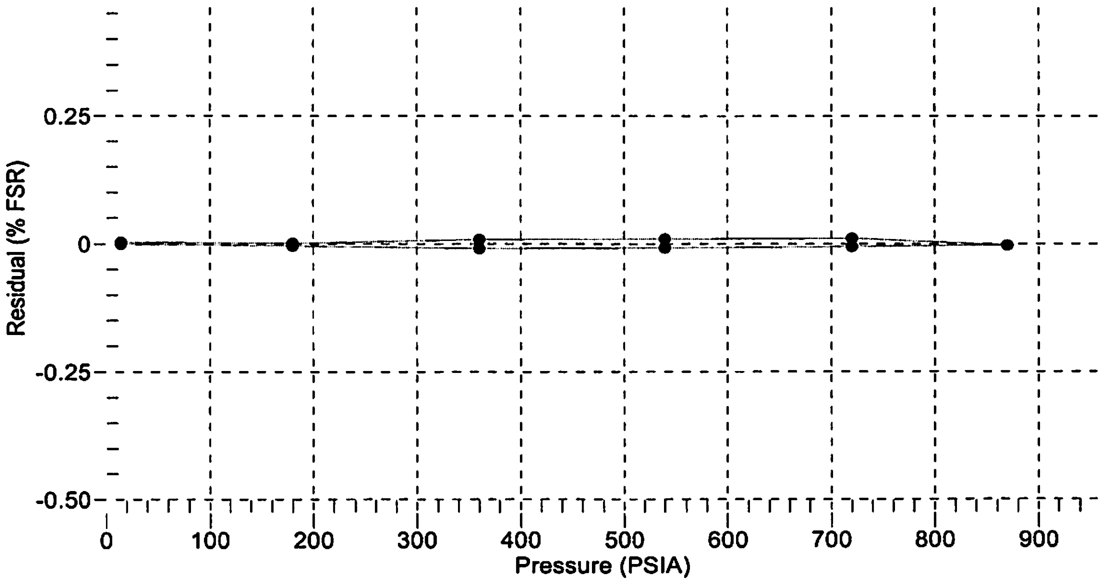
$t = PTEMPA0 + PTEMPA1 * y + PTEMPA2 * y^2$

$x = \text{instrument output} - PTCA0 - PTCA1 * t - PTCA2 * t^2$

$n = x * PTCB0 / (PTCB0 + PTCB1 * t + PTCB2 * t^2)$

$\text{pressure (PSIA)} = PA0 + PA1 * n + PA2 * n^2$

Residual (%FSR) = (computed pressure - true pressure) * 100 / Full Scale Range



SERVICE REPORT

Service Request **1005506708**
Date 17-MAY-2019
Sales Order 315443269

PRODUCT INFORMATION

Item: 05M.LEGACY
Item Description: (LEGACY) SBE 05M Submersible Pump
Serial: 051323

Special Notes
Services Requested:
Evaluate/Repair Instrumentation.

Services Performed:
Perform initial diagnostic evaluation.

Global Service Report

Engineering Services

TELEDYNE MARINE
Everywhereyoulook™

Equipment Registered

RMA no.:	**533993**	Service Report version:	**Version 1**
RMA handled by:	Teledyne RESON DK	RMA repaired by:	Teledyne RESON DK

Customer name: **NOAA Marine Operations Center, Atlantic**

Customer contact: Michael Peperato

Customer email: chiefet.thomas.jefferson@noaa.gov

Customer phone no.:

Category:	SVP Online - TM Imaging	Sub-category:	SVP-71

Service requested: **SVP - Inspection, Repair, Shallow Water Calibration**

Equipment received:

Part no.	Part Description	Serial no.	Rev. no.	Qty
900-00-0000-00	SVP-71 Unit without accessoriesExcl. installation cableExcl. ...	0710064		1

Remarks re. the equipment received:

Failure Analysis

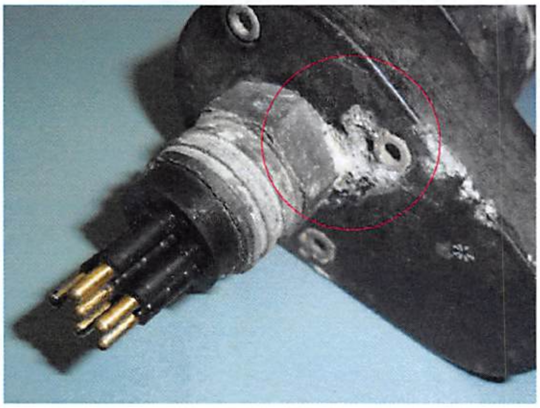
CUSTOMER Failure Description:

"Sent for calibration"

TELEDYNE RESON Analysis tests:

SVP Online Tests	Passed	Failed	Remarks
SVP Visual inspection	○	●	
System communication test	●	○	
Functional test SVP 70/71/C	○	●	

Pictures:



Picture # 1
Connector /end piece corrosion

Picture # 2
Transducer

TELEDYNE RESON Failure Analysis / Investigation:

Testing showed that the transducer is no longer outputting sufficient signal and is therefor in need of replacement.

The SVP is dangerously corroded at the wet end connector/ end piece. Risk of water ingress is present if not the end piece and connector is replaced.

Spare parts / service items required to perform the repair:

Part no.	Part description	Qty
M7213E061_003	Endpiece 1 Anodized	1
7213C10	EM7213 transducer SVP 71	1
CUBIRNSMCBH6M	Birns MCBH6M	1
D8OFAØ24*14	Offeranode Zink Ø24*14	1
87650018	SVP Reson Service Fee - Insp. + 50m Cal.+ Rep. (only SVP70/71),(Inspection+Calibration+R...	1

TELEDYNE RESON Recommended Repair:

Replacement of
End piece(M7213E061_003),
transducer (7213C10),
Birns wet end connector (CUBIRNSMCBH6M)
Offer anode (D8OFAØ24*14)

Alternatively -> Replacement to a new Titanium version (SVP70).

Please note that this quotation is based upon this service report's failure analysis including our initial test of the system as received. In the event that we find additional faults after having started the repair, we reserve the right to revert with a revised proposal for remediation.

Repair and Testing

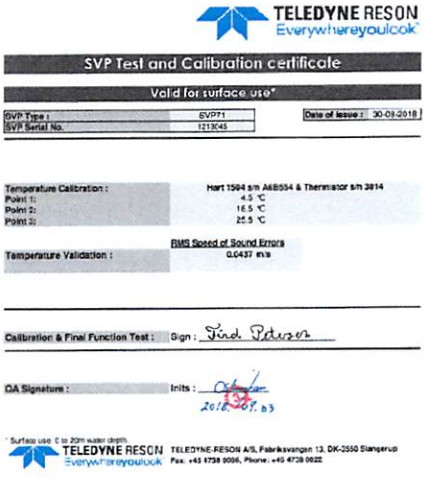
Repair performed: ○ To be repaired ● Repaired ○ **Not** Repaired

- Repaired as described
- Housing has also been replaced due to the extensive corrosion damage, this has been don for free.
- SVP has passed all acoustically tests successfully.

TELEDYNE RESON post-repair tests:

SVP Online Tests	Passed	Failed	**Remarks**
Other	●	○	

Post-repair pictures:



TELEDYNE RESON
Everywhereyoulook

SVP Test and Calibration certificate

Valid for surface use*

SVP Type :	SVP71
SVP Serial No.	1213045

Date of issue : 30-08-2018

Temperature Calibration :	Hart 1594 s/n A6B534 & Thermistor s/n 3014
Point 1:	4.5 ℃
Point 2:	16.5 ℃
Point 3:	25.5 ℃

	RMS Speed of Sound Errors
Temperature Validation :	0.0437 m/s

Calibration & Final Function Test : Sign : Find Petersen

QA Signature : Inits :
2018.09.03

* Surface use: 0 to 20m water depth.

TELEDYNE RESON Everywhereyoulook TELEDYNE-RESON A/S, Fabriksvangen 13, DK-3550 Slangerup
Fax. +45 4738 0066, Phone: +45 4738 0022

Picture # 1	Picture # 2
SVP-71 SN 1213045	Test Certificate

TELEDYNE RESON
Everywhereyoulook™

SVP Test and Calibration certificate

Valid for surface use*

SVP Type :	SVP71
SVP Serial No.	1213045

Date of issue : 30-08-2018

Temperature Calibration :	**Hart 1504 s/n A6B554 & Thermistor s/n 3014**
Point 1:	4.5 ℃
Point 2:	16.5 ℃
Point 3:	25.5 ℃

	RMS Speed of Sound Errors
Temperature Validation :	**0.0437 m/s**

Calibration & Final Function Test : **Sign :** Find Petersen

QA Signature : **Inits :**

3

2018.09.03

* Surface use: 0 to 20m water depth.

TELEDYNE RESON
Everywhereyoulook™
TELEDYNE-RESON A/S, Fabriksvangen 13, DK-3550 Slangerup
Fax: +45 4738 0066, Phone: +45 4738 0022

Global Service Report

Engineering Services

Equipment Registered

RMA no.:	**533991**	Service Report version:	**Version 1**
RMA handled by:	Teledyne RESON DK	RMA repaired by:	Teledyne RESON DK

Customer name:	**NOAA Marine Operations Center, Atlantic**
Customer contact:	Michael Peperato
Customer email:	chiefet.thomas.jefferson@noaa.gov
Customer phone no.:	

Category:	SVP Online - TM Imaging	Sub-category:	SVP-71
Service requested:	**SVP - Inspection, Repair, Shallow Water Calibration**		

Equipment received:

Part no.	Part Description	Serial no.	Rev. no.	Qty
900-00-0000-00	SVP-71 Unit without accessoriesExcl. installation cableExcl. ...	4211065		1

Remarks re. the equipment received:

Failure Analysis

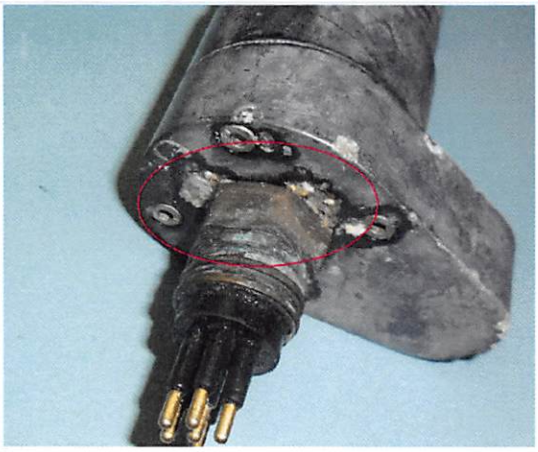
CUSTOMER Failure Description:

"Sent for calibration"

TELEDYNE RESON Analysis tests:

SVP Online Tests	Passed	Failed	**Remarks**
SVP Visual inspection	○	●	Corrosion
System communication test	●	○	
Functional test SVP 70/71/C	○	●	Failed to pass initial tests

Pictures:



Picture # 1

Picture # 2

TELEDYNE RESON Failure Analysis / Investigation:

The SVP is dangerously corroded at the wet end connector, which can soon lead to water ingress damages. The wet end connector is also is also starting to leak electronically from one of the connector pins to ground. Therefore the end piece and the wet end connector needs replacement to avoid further damages.

Testing showed that the transducer is no longer outputting sufficient signal and is therefor in need of replacement.

Spare parts / service items required to perform the repair:

Part no.	**Part description**	**Qty**
M7213E061_003	Endpiece 1 Anodized	1
7213C10	EM7213 transducer SVP 71	1
CUBIRNSMCBH6M	Birns MCBH6M	1
D8OFAØ24*14	Offeranode Zink Ø24*14	1
87650018	SVP Reson Service Fee - Insp. + 50m Cal.+ Rep. (only SVP70/71),(Inspection+Calibration+R...	1

TELEDYNE RESON Recommended Repair:

Replacement of:
End piece(M7213E061_003),
transducer (7213C10),
Birns wet end connector (CUBIRNSMCBH6M)
Offer anode (D8OFAØ24*14).

-Alternatively - Replacement to a Titanium version (SVP70).

Please note that this quotation is based upon this service report's failure analysis including our initial test of the system as received. In the event that we find additional faults after having started the repair, we reserve the right to revert with a revised proposal for remediation.

Repair and Testing

Repair performed: ○ To be repaired ● Repaired ○ **Not** Repaired

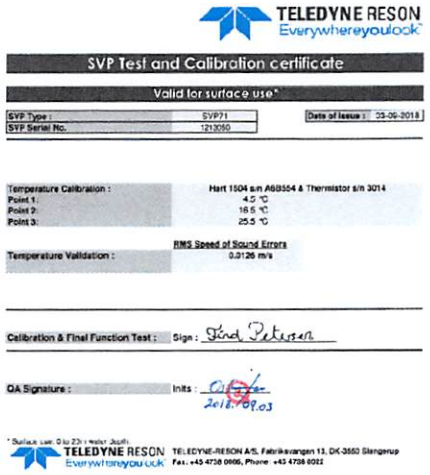
- Repaired as described
- Housing has also been replaced due to the extensive corrosion damage, this has been don for free.
- SVP has passed all acoustically tests successfully.

TELEDYNE RESON post-repair tests:

SVP Online Tests	Passed	Failed	**Remarks**
Other	●	○	

Post-repair pictures:

Picture # 1
SVP-71 SN 1213050



TELEDYNE RESON
Everywhereyoulook

SVP Test and Calibration certificate

Valid for surface use*

SVP Type :	SVP71
SVP Serial No.	1213050

Date of issue : 03-09-2018

Temperature Calibration :	Hart 1504 s/n A6B554 & Thermistor s/n 3014
Point 1:	4.5 °C
Point 2:	16.5 °C
Point 3:	25.5 °C
	RMS Speed of Sound Errors
Temperature Validation :	0.0126 m/s

Calibration & Final Function Test : Sign : Find Petersen

QA Signature : Inits : 2018.09.03

TELEDYNE RESON Everywhereyoulook TELEDYNE-RESON A/S, Fabriksvangen 13, DK-3550 Slangerup
Fax.: +45 4738 0066, Phone: +45 4738 0022

Picture # 2
Test Certificate

TELEDYNE RESON
Everywhereyoulook™

SVP Test and Calibration certificate

Valid for surface use*

SVP Type :	SVP71
SVP Serial No.	1213050

Date of issue : 03-09-2018

Temperature Calibration :	**Hart 1504 s/n A6B554 & Thermistor s/n 3014**
Point 1:	4.5 °C
Point 2:	16.5 °C
Point 3:	25.5 °C

	RMS Speed of Sound Errors
Temperature Validation :	**0.0126 m/s**

Calibration & Final Function Test : Sign : Find Petersen

QA Signature : Inits :

RESON 3

2018.09.03

* Surface use: 0 to 20m water depth.

Vessel offset Reports

U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Ocean Service
National Geodetic Survey
Field Operations Branch

Thomas Jefferson Launch 2903
Component Spatial Relationship Survey
Field Report

Kevin Jordan
May 1, 2017

PURPOSE

The intention of this survey was to accurately position the POS/MV IMU, GPS Antennas, Receiver and Transmitter, Side Scan Reference Marks and bench marks on TJ launch 2903.

PROJECT DETAILS

This survey was conducted on May 1, 2017 at NOAA's Marine Operations Center in Norfolk, VA . The boat was on jack stands and leveled. The temperature was around 70 degrees and winds 10-15 mph.

INSTRUMENTATION

The TOPCON GPT 3000 Series Theodolite was used to position all points on the launch.

A SECO 25 mm Mini Prism System configured to have a zero mm offset was used as target sighting and distance measurements.

SOFTWARE AND DATA COLLECTION

TDS Survey Pro Ver. 5.7.2

ForeSight DXM Ver. 3.2.2 was used for post processing.

PERSONNEL

Kevin Jordan	NOAA/NOS/NGS/Field Operations Branch	757-441-5467
Jim Harrington	NOAA/NOS/NGS/Field Operations Branch	757-441-5496
Ryan Hippenstiel	NOAA/NOS/NGS/Field Operations Branch	757-441-6595

Temporary Control

A network of temporary control was established on the lot consisting or two marks set on solid ground about 60 meters apart. These points were named TP 1 and TP 2. The majority of observations were performed using one setup on TP 1. TP 2 was utilized to setup the instrument and observe two additional points on the hull of the boat.

OBSERVED POINTS

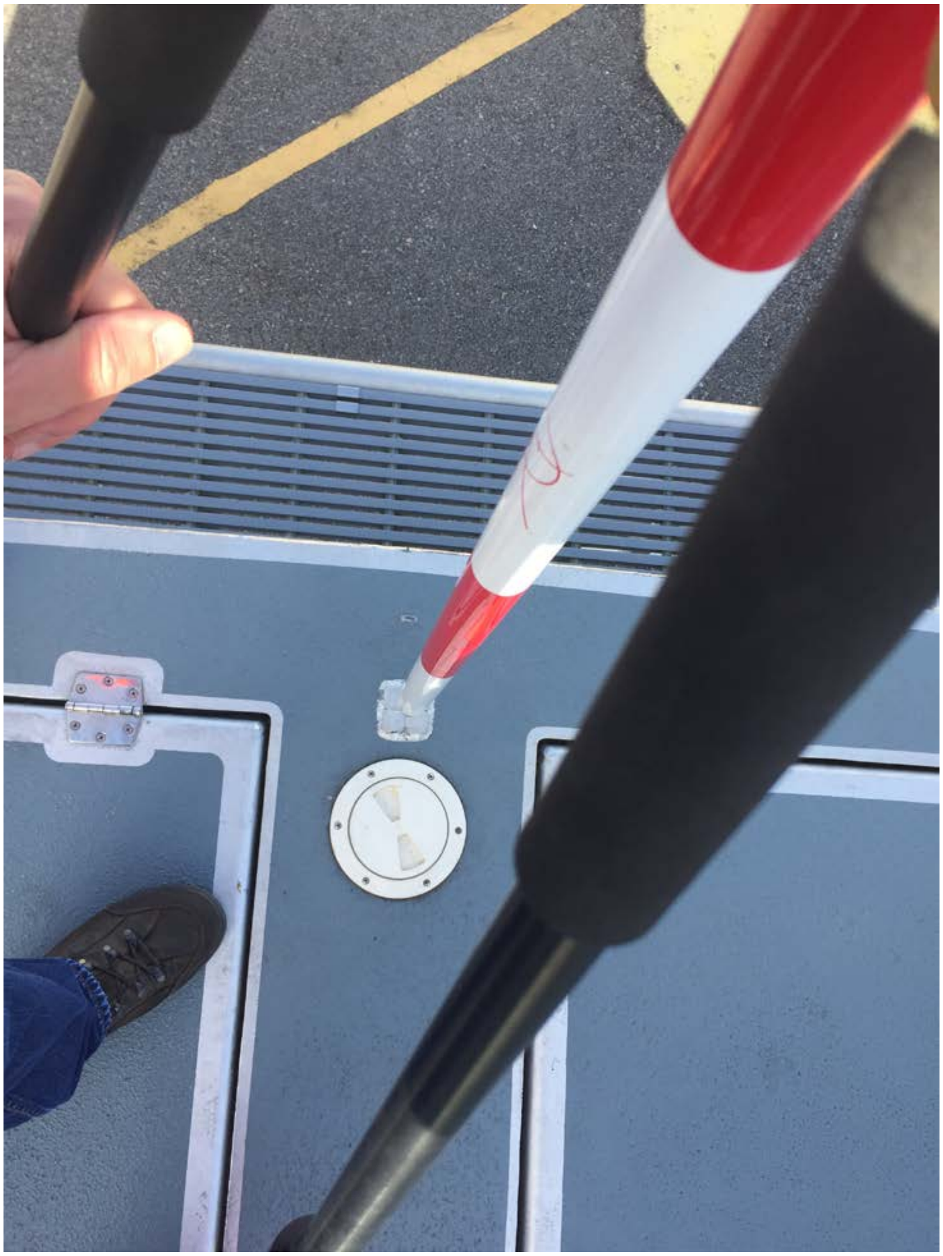
IMU

CL 1

CL 2

CL 3

CL 4



BM PORT 3

BM PORT 2

BM PORT 1

BM STAR 3

BM STAR 2

BM STAR 1

GPS PORT ARP

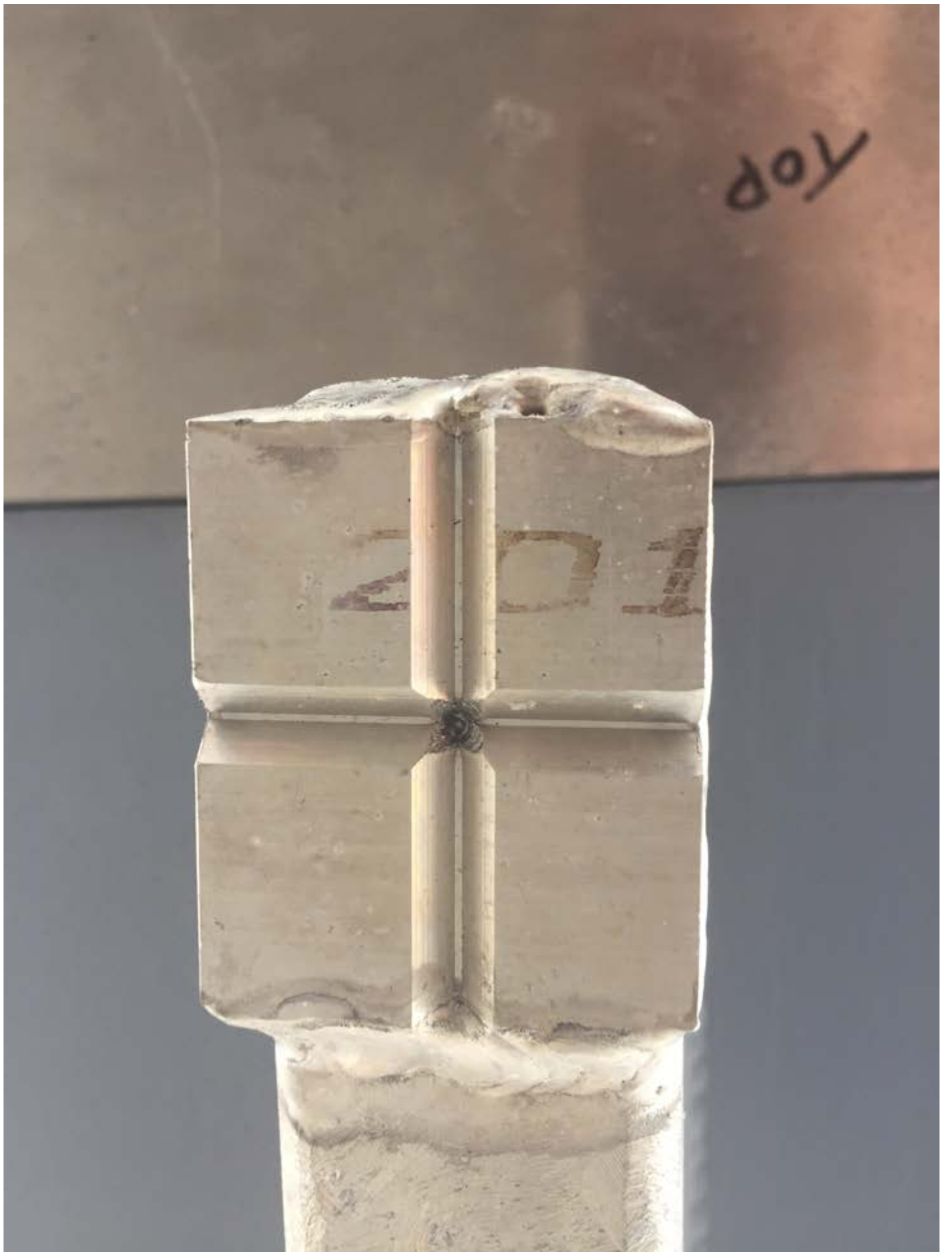
GPS STAR ARP

SIDE SCAN TOW POINT RM

RECEIVER

TRANSMITTER

KEEL BM FWD

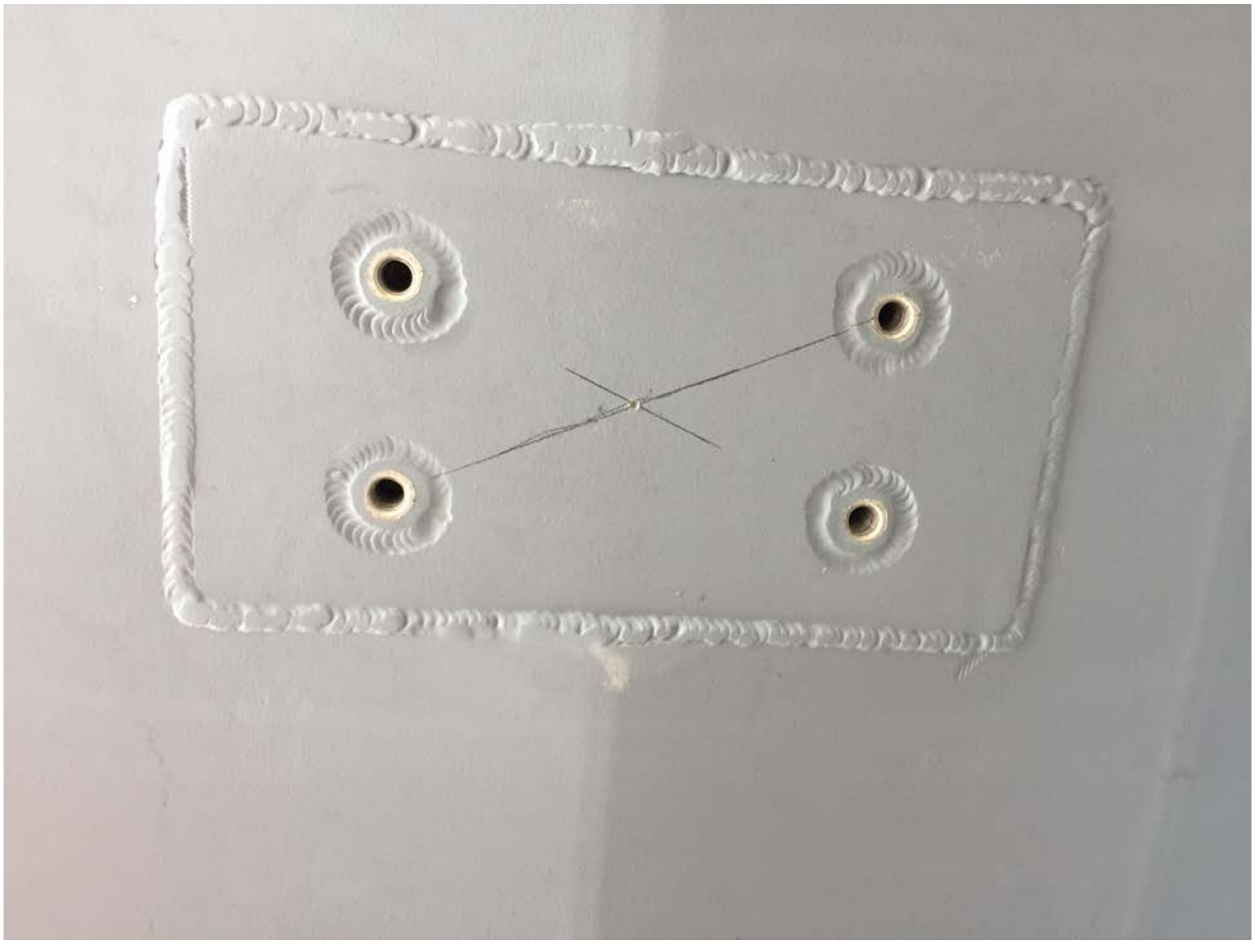


KEEL BM AFT

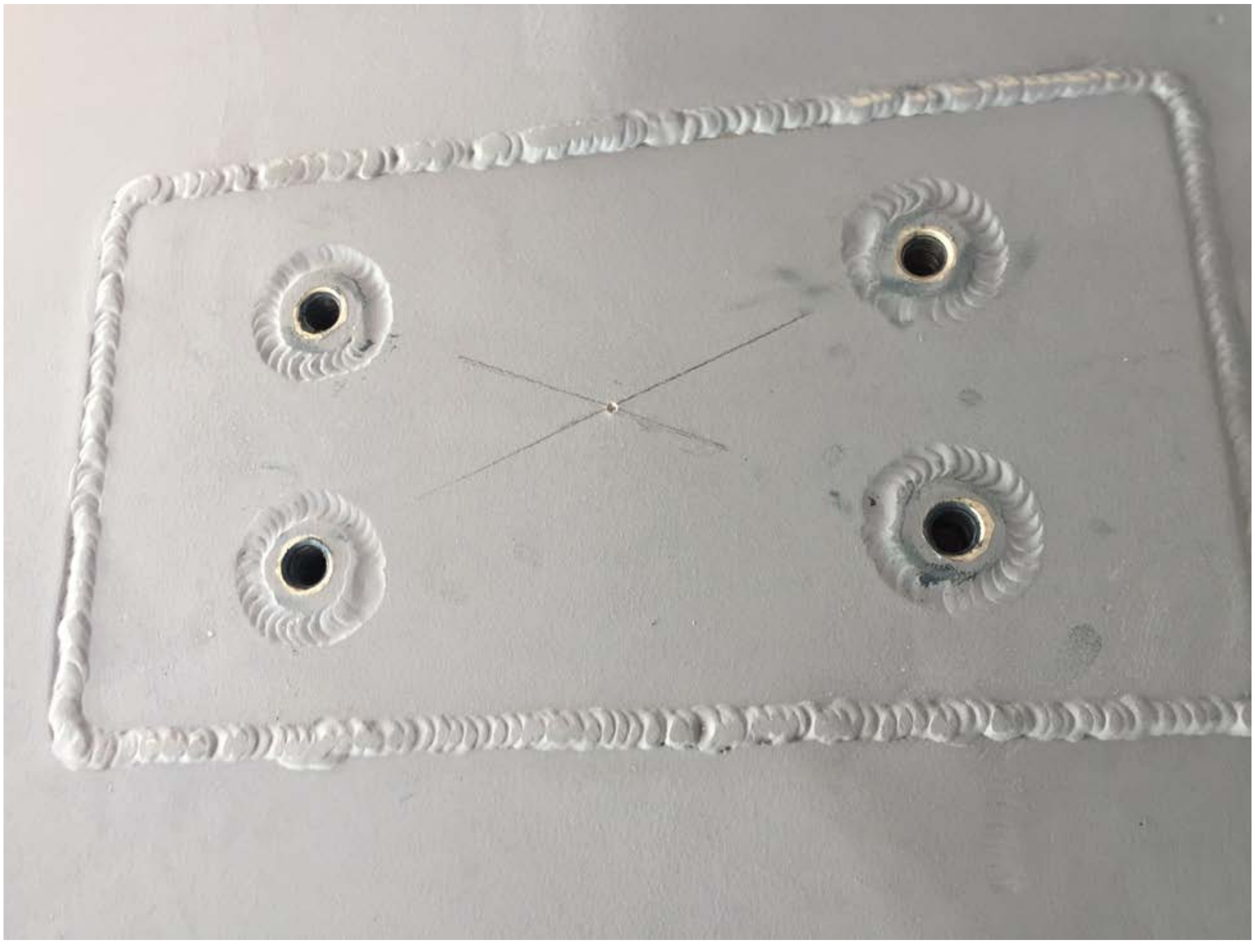
PORT SIDE SCAN HARD POINT FWD

PORT SIDE SCAN HARD POINT AFT

STAR SIDE SCAN HARD POINT FWD



STAR SIDE SCAN HARD POINT AFT



POST PROCESSING

The collected points were surveyed in an assumed coordinate system and needed to be translated to the point “IMU” as X=0, Y=0, Z=0. The azimuth from CL 4 to CL 1 needed to be oriented to 0° 00’ 00”. Post Processing was performed using ForeSight DXM to produce the following Coordinate Report. The X Axis is Positive toward the Bow. The Y Axis is positive toward the Starboard side. The Z Axis is positive downward.

Transmitter center

The transmitter center was determined by measuring the length and width of the face (fwd to aft, port to starboard) and splitting the difference of the measurement. A temporary mark was placed on a piece of masking tape and measured.

Side Scan Tow Point Reference Mark

A reference mark for the Side Scan Sonar was established as part of this survey. The point of measurement can be described as a “.” punch mark below the port-facing middle bracket on the side-scan arm.

Final Coordinate List

An excel spreadsheet labeled TJ_2903.xlsx is included with the project submission. Below is a report of the final coordinate listing.

2903 Boat Survey 2017

NAME	**X (METERS)**	**Y (METERS)**	**Z (METERS)**
IMU	0.000	0.000	0.000
CL1	3.591	0.002	-1.322
CL3	-0.212	0.012	-0.657
CL2	-0.145	0.029	-2.651
CL4	-4.020	0.002	-0.742
BM PORT 3	-1.581	-0.618	-2.671
BM PORT 2	-0.702	-0.467	-3.043
BM PORT 1	0.174	-1.424	-1.069
BM STAR 3	-1.581	0.692	-2.667
BM STAR 2	-0.698	0.509	-3.046
BM STAR 1	0.170	1.440	-1.052
GPS PORT ARP	-0.693	-0.710	-3.572
GPS STAR ARP	-0.680	0.746	-3.579
SIDE SCAN TOW POINT RM	-5.307	-0.015	-3.121
RECEIVER	0.263	0.000	0.530
TRANSMITTER	0.044	-0.005	0.532
KEEL BM FWD	0.455	0.001	0.632
KEEL BM AFT	-0.577	0.002	0.716
PORT SIDE SCAN HARD POINT FWD	1.102	-0.561	0.303
PORT SIDE SCAN HARD POINT AFT	0.188	-0.566	0.307
STAR SIDE SCAN HARD POINT FWD	1.105	0.554	0.322
STAR SIDE SCAN HARD POINT AFT	0.195	0.572	0.319

***NOTE Z VALUES ARE POSITIVE DOWNWARD**

SURVEY CLOSURE

The majority of points were established by occupying a temporary mark (TP 1) established on solid ground about 11 meters behind the stern of the boat. Throughout the survey, Horizontal and Vertical checks were made to the 2nd temporary point that was established on the lot (TP 2). At the end of the observations, a check point was collected and an inverse was computed.

TP 2
Δ X = 0.001 m
Δ Y = 0.003 m
Δ Z = 0.005 m

A second setup was required to collect two additional points. The instrument was setup on TP 2 and backsight TP 1. The initial survey setup checked TP 1 by:

CK TP 1
Δ X = 0.001 m
Δ Y = 0.000 m
Δ Z = 0.003 m

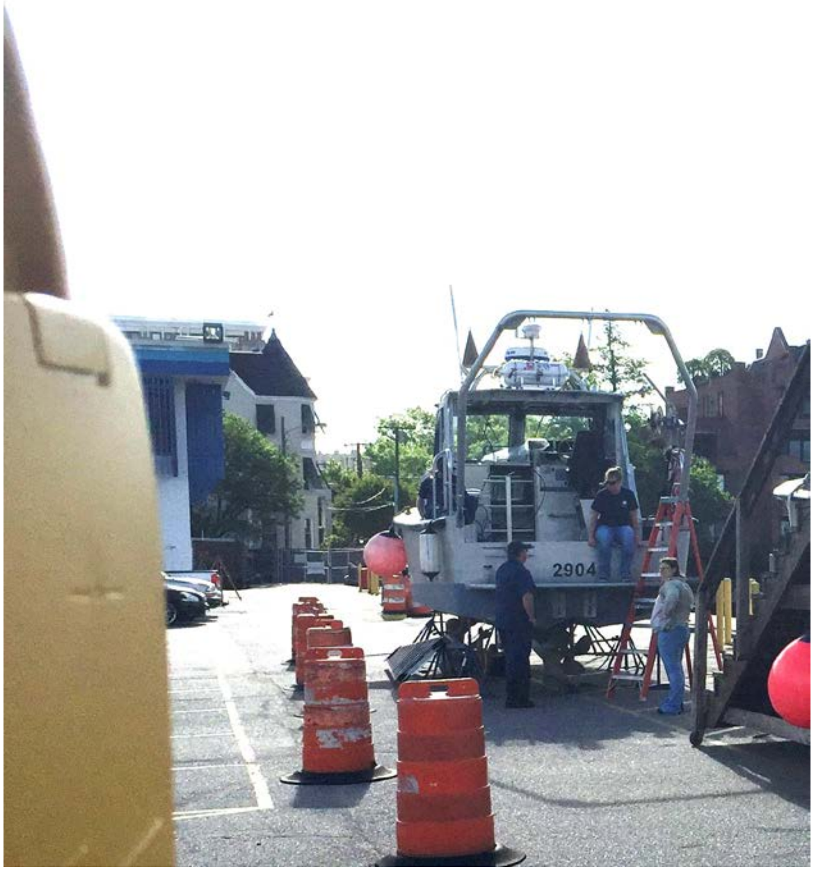
Following the collection of the additional points, a final check to TP 1 was performed and closure was:

CK TP 1
Δ X = 0.001 m
Δ Y = 0.001 m
Δ Z = 0.001 m

U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Ocean Service
National Geodetic Survey
Field Operations Branch

Thomas Jefferson Launch 2904
Component Spatial Relationship Survey
Field Report

Kevin Jordan
May 1, 2017



PURPOSE

The intention of this survey was to accurately position the POS/MV IMU, GPS Antennas, Receiver and Transmitter, Side Scan Reference Marks and bench marks on TJ launch 2904.

PROJECT DETAILS

This survey was conducted on May 1, 2017 at NOAA's Marine Operations Center in Norfolk, VA . The boat was on jack stands and leveled. The temperature was around 70 degrees and winds 10-15 mph.

INSTRUMENTATION

The TOPCON GPT 3000 Series Theodolite was used to position all points on the launch.

A SECO 25 mm Mini Prism System configured to have a zero mm offset was used as target sighting and distance measurements.

SOFTWARE AND DATA COLLECTION

TDS Survey Pro Ver. 5.7.2

ForeSight DXM Ver. 3.2.2 was used for post processing.

PERSONNEL

Kevin Jordan	NOAA/NOS/NGS/Field Operations Branch	757-441-5467
Jim Harrington	NOAA/NOS/NGS/Field Operations Branch	757-441-5496
Ryan Hippenstiel	NOAA/NOS/NGS/Field Operations Branch	757-441-6595

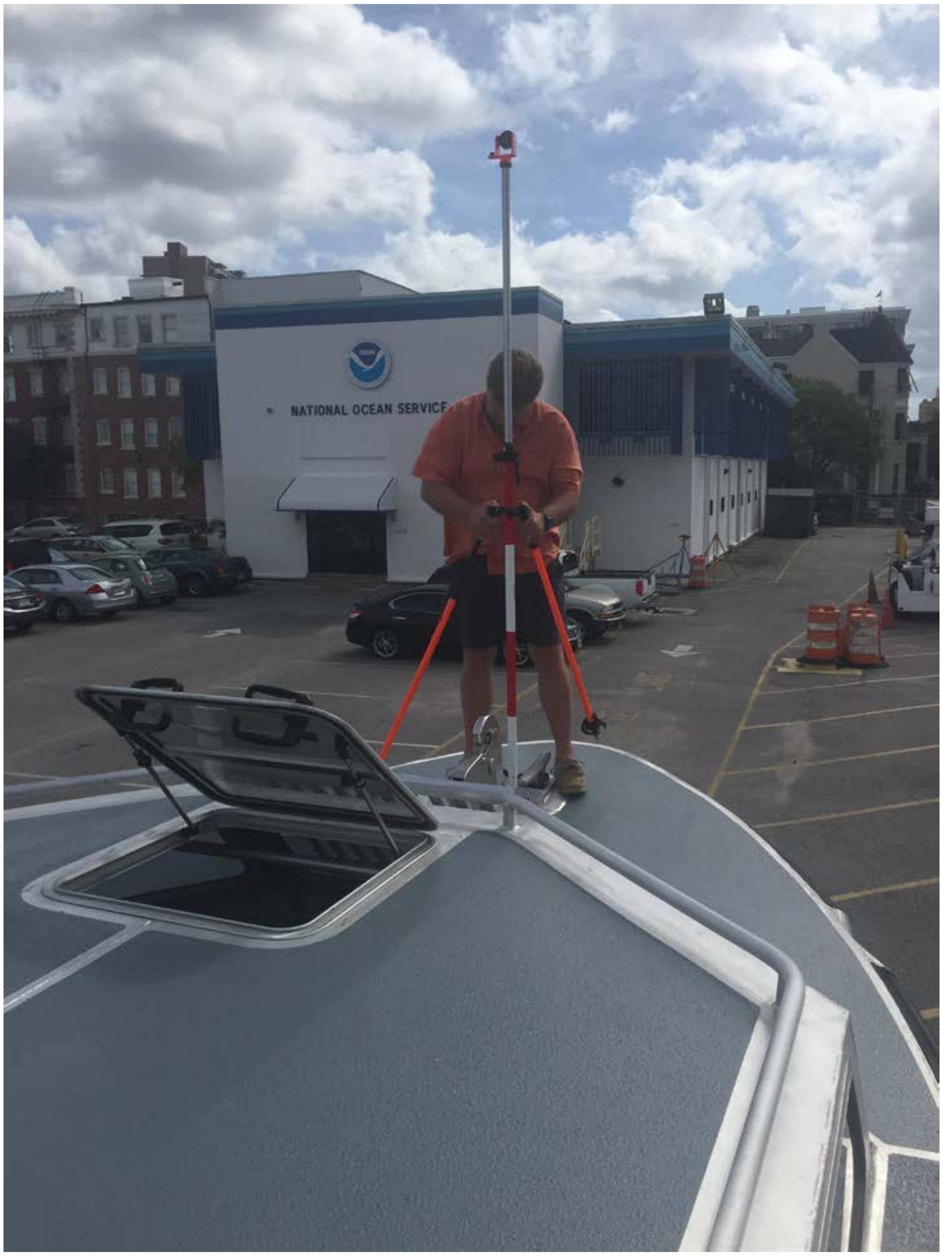
Temporary Control

A network of temporary control was established on the lot consisting or two marks set on solid ground about 60 meters apart. These points were named TP 1 and TP 2. The majority of observations were performed using one setup on TP 1. TP 2 was utilized to setup the instrument and observe two additional points on the hull of the boat.

OBSERVED POINTS

IMU

CL 1



CL 2

CL 3

CL 4

BM PORT 3

BM PORT 2

BM PORT 1

BM STAR 3

BM STAR 2

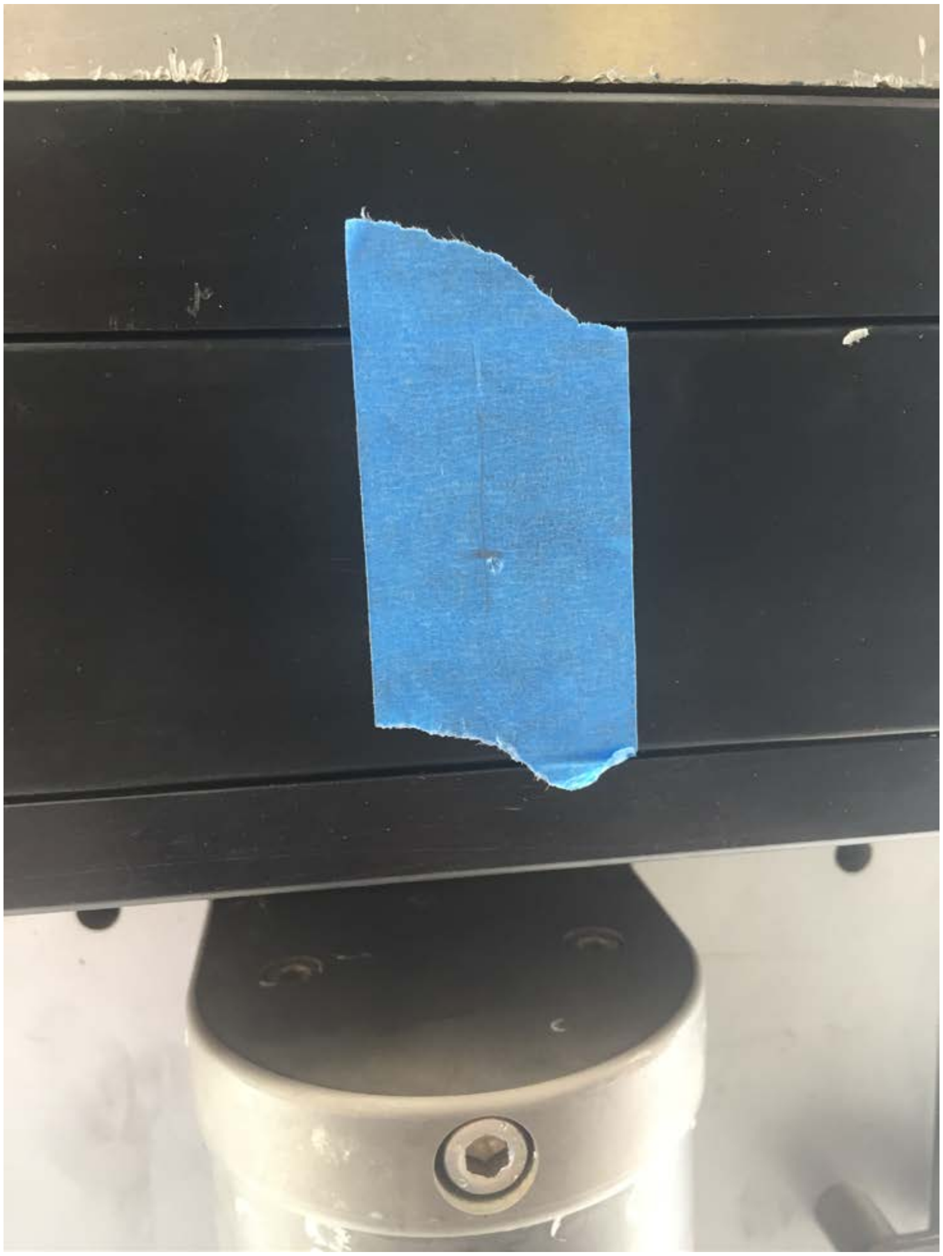
BM STAR 1

GPS PORT ARP

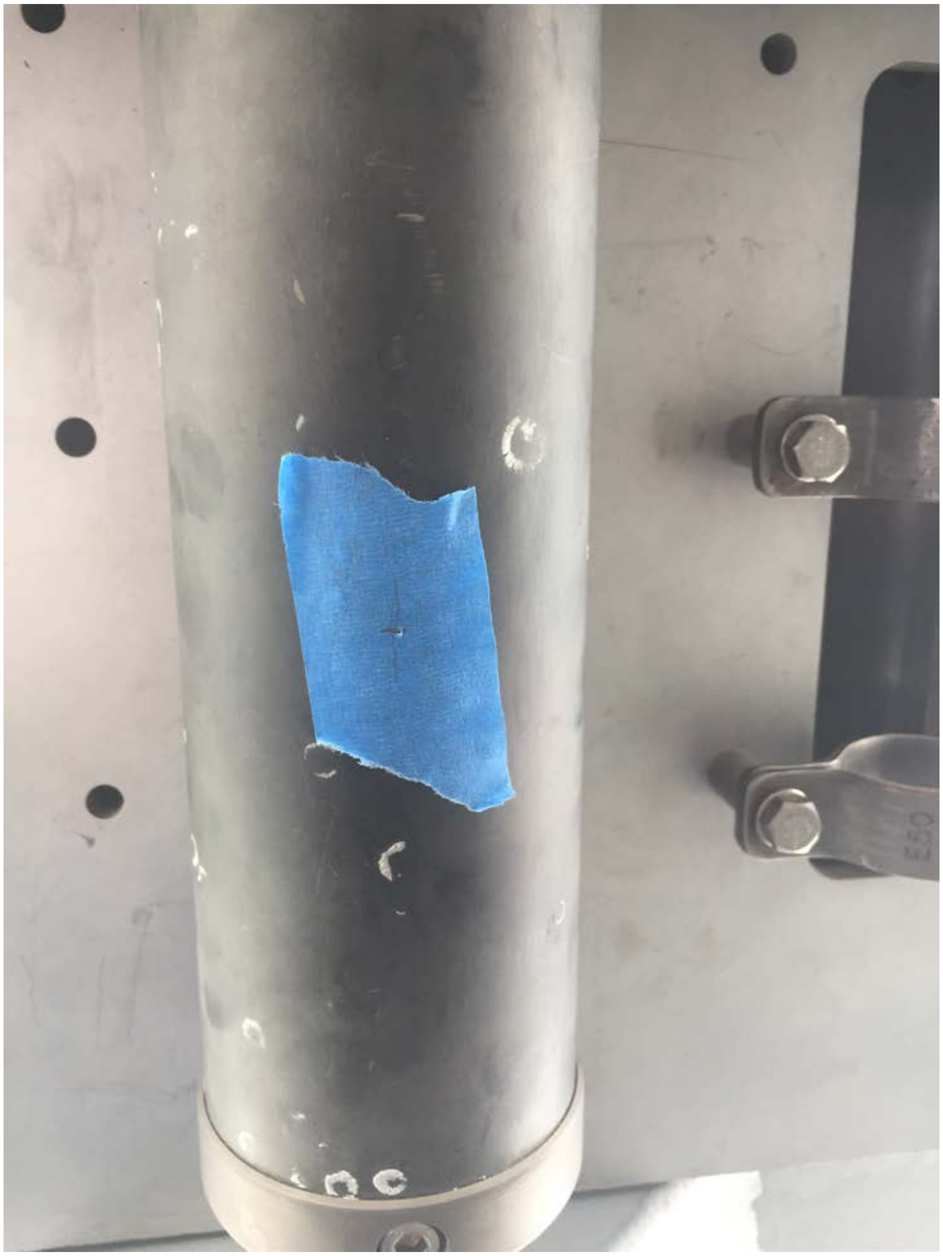
GPS STAR ARP

SIDE SCAN TOW POINT RM

RECEIVER



TRANSMITTER



KEEL BM FWD

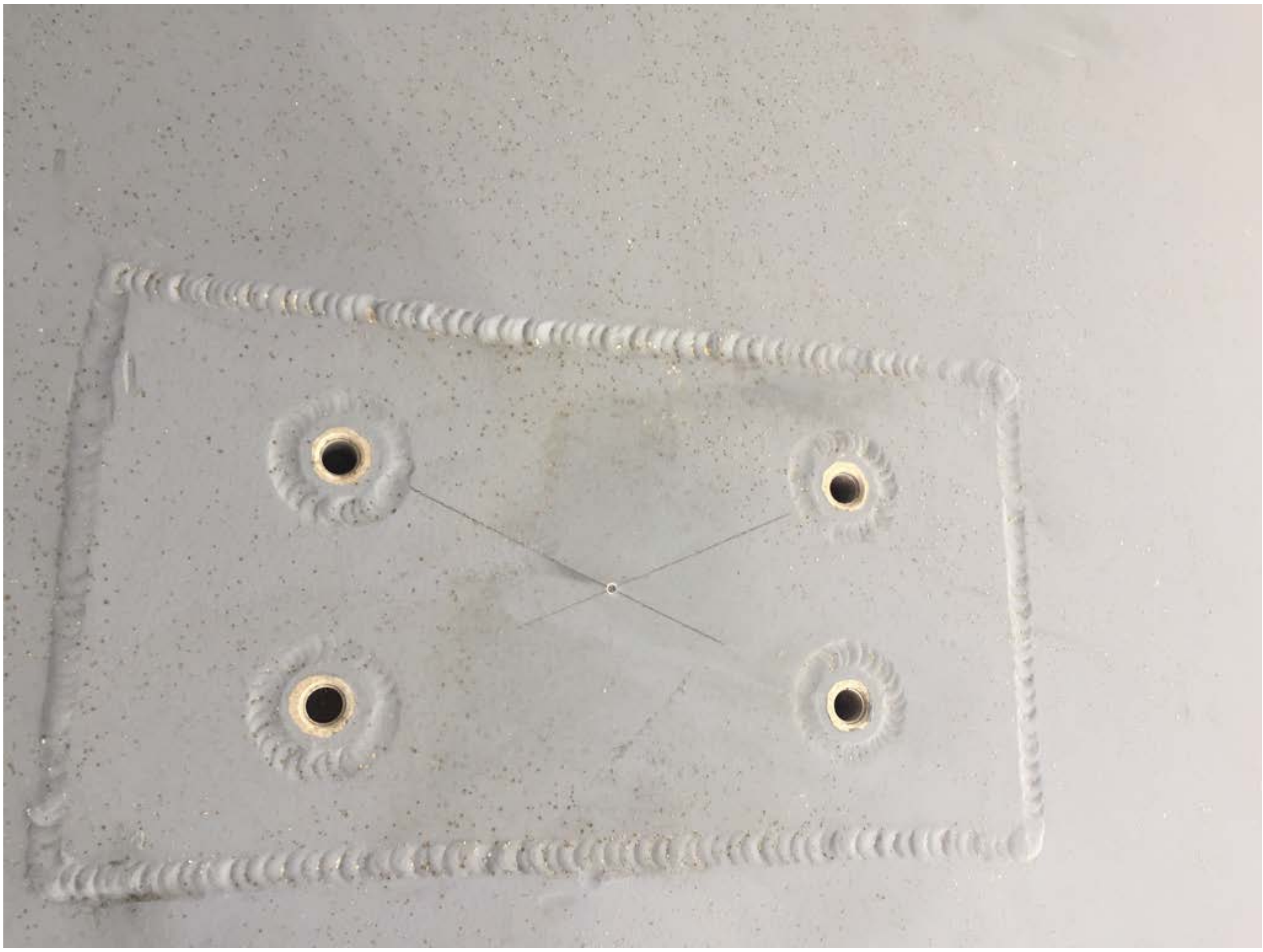
KEEL BM AFT

PORT SIDE SCAN HARD POINT FWD

PORT SIDE SCAN HARD POINT AFT

STAR SIDE SCAN HARD POINT FWD

STAR SIDE SCAN HARD POINT AFT



POST PROCESSING

The collected points were surveyed in an assumed coordinate system and needed to be translated to the point “IMU” as X=0, Y=0, Z=0. The azimuth from CL 4 to CL 1 needed to be oriented to 0° 00’ 00”. Post Processing was performed using ForeSight DXM to produce the following Coordinate Report. The X Axis is Positive toward the Bow. The Y Axis is positive toward the Starboard side. The Z Axis is positive downward.

Transmitter center

The transmitter center was determined by measuring the length and width of the face (fwd to aft, port to starboard) and splitting the difference of the measurement. A temporary mark was placed on a piece of masking tape and measured.

Side Scan Tow Point Reference Mark

A reference mark for the Side Scan Sonar was established as part of this survey. The point of measurement can be described as a "." punch mark on the left-most middle bracket and is aft-facing on the side-scan arm.

Final Coordinate List

An excel spreadsheet labeled TJ_2904.xlsx is included with the project submission. Below is a report of the final coordinate listing.

2904 Boat Survey 2017

NAME	**X (METERS)**	**Y (METERS)**	**Z (METERS)**
IMU	0.000	0.000	0.000
CL1	3.583	-0.011	-1.358
CL3	-0.212	-0.004	-0.649
CL2	-0.171	-0.011	-2.653
CL4	-4.014	-0.012	-0.686
BM PORT 3	-1.598	-0.678	-2.648
BM PORT 2	-0.738	-0.549	-3.040
BM PORT 1	0.185	-1.453	-1.052
BM STAR 3	-1.607	0.649	-2.649
BM STAR 2	-0.743	0.533	-3.041
BM STAR 1	0.146	1.434	-1.060
GPS PORT ARP	-0.725	-0.762	-3.562
GPS STAR ARP	-0.730	0.726	-3.567
SIDE SCAN TOW POINT RM	-5.477	-0.061	-3.035
RECEIVER	0.269	-0.007	0.529
TRANSMITTER	0.050	0.000	0.535
KEEL BM FWD	0.467	0.003	0.631
KEEL BM AFT	-0.570	0.003	0.735
PORT SIDE SCAN HARD POINT FWD	1.130	-0.563	0.301
PORT SIDE SCAN HARD POINT AFT	0.209	-0.563	0.314
STAR SIDE SCAN HARD POINT FWD	1.123	0.579	0.300
STAR SIDE SCAN HARD POINT AFT	0.195	0.568	0.312

***NOTE Z VALUES ARE POSITIVE DOWNWARD**

SURVEY CLOSURE

The majority of points were established by occupying a temporary mark (TP 1) established on solid ground about 20 meters behind the stern of the boat. Throughout the survey, Horizontal and Vertical checks were made to the 2nd temporary point that was established on the lot (TP 2). At the end of the observations, a check point was collected and an inverse was computed.

TP 2
Δ X = 0.000 m
Δ Y = 0.001 m
Δ Z = 0.003 m

A second setup was required to collect two additional points. The instrument was setup on TP 2 and backsight TP 1. The initial survey setup checked TP 1 by:

CK TP 1
Δ X = 0.001 m
Δ Y = 0.000 m
Δ Z = 0.003 m

Following the collection of the additional points, a final check to TP 1 was performed and closure was:

CK TP 1
Δ X = 0.001 m
Δ Y = 0.001 m
Δ Z = 0.001 m

Position and Attitude Sensor Calibration Reports

POS/MV Calibration Report

Field Unit: Thomas Jefferson

SYSTEM INFORMATION

Vessel: 2903

Date: 5/31/2019 **Dn:** 151

Personnel: Grains, Wisotzkey, Cziraki, Arboleda

PCS Serial #

IP Address: 192.100.1.231

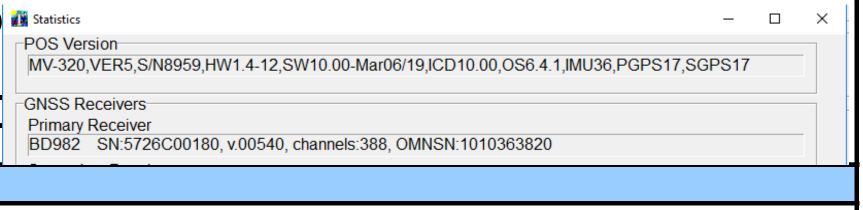
POS controller Version (Use Menu Help > About) 10

POS Version (Use Menu View > Statistics)

GPS Receivers

Primary Receiver

Secondary Receiver



POS Version

MV-320,VER5,S/N8959,HW1.4-12,SW10.00-Mar06/19,ICD10.00,OS6.4.1,IMU36,PGPS17,SGPS17

GNSS Receivers

Primary Receiver

BD982 SN:5726C00180, v.00540, channels:388, OMNSN:1010363820

CALIBRATION AREA

Location: Lamber's Point

Approximate Position:

		D	M	S
	Lat	36	51	50
	Lon	76	19	

DGPS Beacon Station: 138

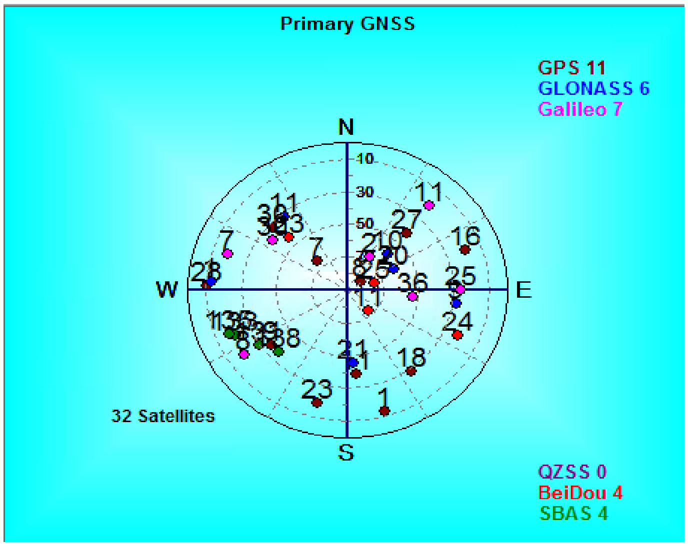
Frequency:

Satellite Constellation

Primary GPS (Port Antenna)

(Use View> GPS Data)

N



HDOP: 0.732

VDOP: 1.254

Sattelites in Use:

PDOP 1.200 (Use View> GAMS Solution)

Note:

POS/MV CONFIGURATION

Settings

Gams Parameter Setup (Use Settings > Installation > GAMS Intallation)

User Entries, Pre-Calibration

1.435	Two Antenna Separation (m)
0.50	Heading Calibration Threshold
0	Heading Correction

Baseline Vector

0	X Component (m)
1.423	YComponent (m)
-0.017	Z Component (m)

Configuration Notes:

POS/MV CALIBRATION

Calibration Procedure:

(Refer to POS MV V3 Installation and Operation Guide, 4-25)

Start time: 1505

End time: 1509

Heading accuracy achieved for calibration: 0.162

Calibration Results:

Gams Parameter Setup (Use Settings > Installation > GAMS Intallation)

POS/MV Post-Calibration Values

1.437	Two Antenna Separation (m)
0.500	Heading Calibration Threshold
0	Heading Correction

Baseline Vector

-0.007	X Component (m)
1.435	YComponent (m)
-0.049	Z Component (m)

GAMS Status Online? Yes

Save Settings? Yes

Calibration Notes:

Save POS Settings on PC (Use File > Store POS Settings on PC)

File Name: PosConfig_WAAS_NoMarinestar_20190531

GENERAL GUIDANCE

The POS/MV uses a Right-Hand Orthogonal Reference System

The right-hand orthogonal system defines the following:

- The x-axis is in the fore-aft direction in the appropriate reference frame.
- The y-axis is perpendicular to the x-axis and points towards the right (starboard) side in the appropriate reference frame.
- The z-axis points downwards in the appropriate reference frame.

The POS/MV uses a Tate-Bryant Rotation Sequence

Apply the rotation in the following order to bring the two frames of reference into complete alignment:

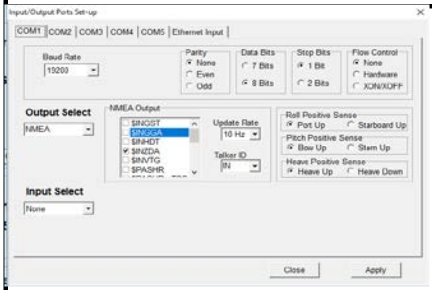
a) Heading rotation - apply a right-hand screw rotation θz about the z-axis to align one frame with the other.

b) Pitch rotation - apply a right-hand screw rotation θy about the once-rotated y-axis to align one frame with the other.

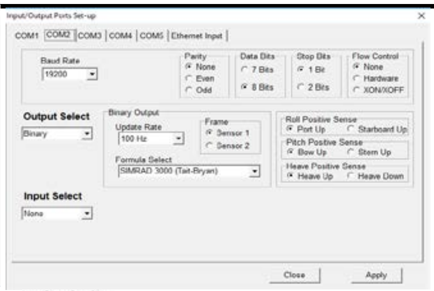
c) Roll rotation - apply a right-hand screw rotation θx about the twice-rotated x-axis to align one frame with the other.

SETTINGS (insert screen grabs)

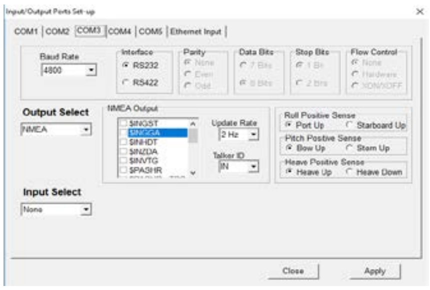
Input/Output Ports (Use Settings > Input/Output Ports)



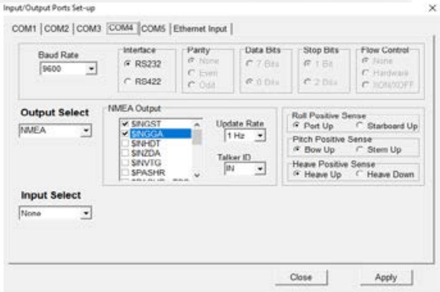
Input/Output Ports Set-up — COM1
Baud Rate: 19200
Parity: ● None ○ Even ○ Odd
Data Bits: ○ 7 Bits ● 8 Bits
Stop Bits: ● 1 Bit ○ 2 Bits
Flow Control: ● None ○ Hardware ○ XON/XOFF
Output Select: NMEA
NMEA Output: ☐ $INGST ☐ $INGGA ☐ $INHDT ☑ $INZDA ☐ $INVTG ☐ $PASHR
Update Rate: 10 Hz
Talker ID: IN
Roll Positive Sense: ● Port Up ○ Starboard Up
Pitch Positive Sense: ● Bow Up ○ Stern Up
Heave Positive Sense: ● Heave Up ○ Heave Down
Input Select: None



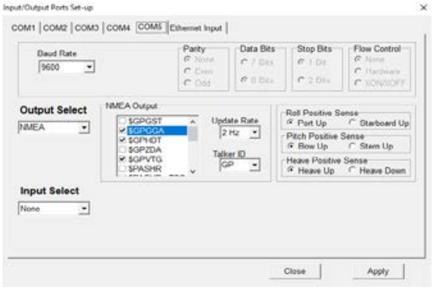
Input/Output Ports Set-up — COM2
Baud Rate: 19200
Parity: ● None ○ Even ○ Odd
Data Bits: ○ 7 Bits ● 8 Bits
Stop Bits: ● 1 Bit ○ 2 Bits
Flow Control: ● None ○ Hardware ○ XON/XOFF
Output Select: Binary
Binary Output
Update Rate: 100 Hz
Frame: ● Sensor 1 ○ Sensor 2
Formula Select: SIMRAD 3000 (Tait-Bryan)
Roll Positive Sense: ● Port Up ○ Starboard Up
Pitch Positive Sense: ● Bow Up ○ Stern Up
Heave Positive Sense: ● Heave Up ○ Heave Down
Input Select: None



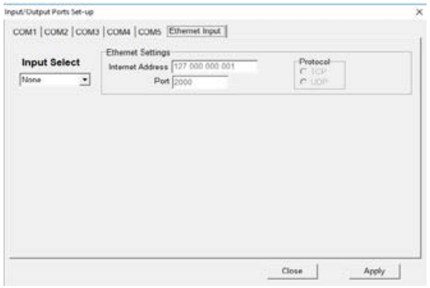
Input/Output Ports Set-up — COM3
Baud Rate: 4800
Interface: ● RS232 ○ RS422
Parity: ● None ○ Even ○ Odd
Data Bits: ○ 7 Bits ● 8 Bits
Stop Bits: ● 1 Bit ○ 2 Bits
Flow Control: ● None ○ Hardware ○ XON/XOFF
Output Select: NMEA
NMEA Output: ☐ $INGST ☐ $INGGA ☐ $INHDT ☐ $INZDA ☐ $INVTG ☐ $PASHR
Update Rate: 2 Hz
Talker ID: IN
Roll Positive Sense: ● Port Up ○ Starboard Up
Pitch Positive Sense: ● Bow Up ○ Stern Up
Heave Positive Sense: ● Heave Up ○ Heave Down
Input Select: None



Input/Output Ports Set-up — COM4
Baud Rate: 9600
Interface: ● RS232 ○ RS422
Parity: ● None ○ Even ○ Odd
Data Bits: ○ 7 Bits ● 8 Bits
Stop Bits: ● 1 Bit ○ 2 Bits
Flow Control: ● None ○ Hardware ○ XON/XOFF
Output Select: NMEA
NMEA Output: ☑ $INGST ☑ $INGGA ☐ $INHDT ☐ $INZDA ☐ $INVTG ☐ $PASHR
Update Rate: 1 Hz
Talker ID: IN
Roll Positive Sense: ● Port Up ○ Starboard Up
Pitch Positive Sense: ● Bow Up ○ Stern Up
Heave Positive Sense: ● Heave Up ○ Heave Down
Input Select: None



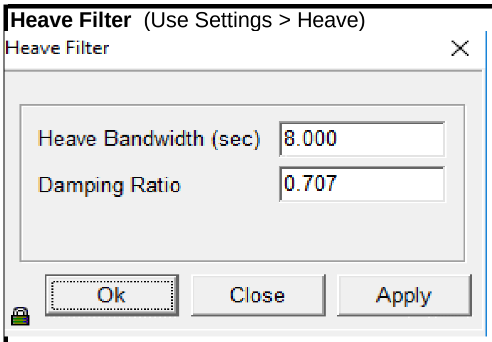
Input/Output Ports Set-up — COM5
Baud Rate: 9600
Parity: ● None ○ Even ○ Odd
Data Bits: ○ 7 Bits ● 8 Bits
Stop Bits: ● 1 Bit ○ 2 Bits
Flow Control: ● None ○ Hardware ○ XON/XOFF
Output Select: NMEA
NMEA Output: ☐ $GPGST ☑ $GPGGA ☑ $GPHDT ☐ $GPZDA ☑ $GPVTG ☐ $PASHR
Update Rate: 2 Hz
Talker ID: GP
Roll Positive Sense: ● Port Up ○ Starboard Up
Pitch Positive Sense: ● Bow Up ○ Stern Up
Heave Positive Sense: ● Heave Up ○ Heave Down
Input Select: None



Input/Output Ports Set-up — Ethernet Input
Input Select: None
Ethernet Settings
Internet Address: 127.000.000.001
Port: 2000
Protocol: ○ TCP ● UDP

NOTE:

Heave Filter (Use Settings > Heave)



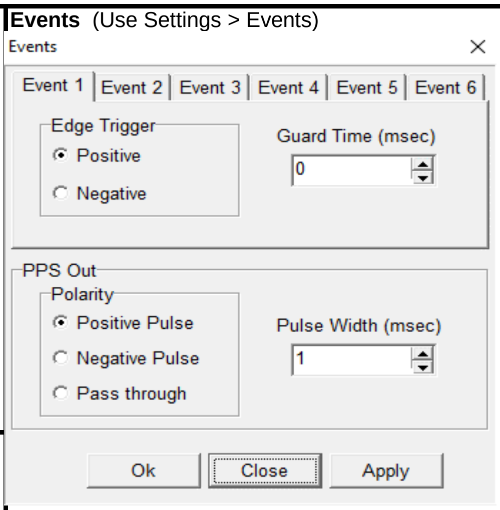
Heave Bandwidth (sec) 8.000

Damping Ratio 0.707

Time Sync (Use Settings > Time Sync)

NOT ON THE VERSION 5

Events (Use Settings > Events)



Edge Trigger: ● Positive ○ Negative

Guard Time (msec) 0

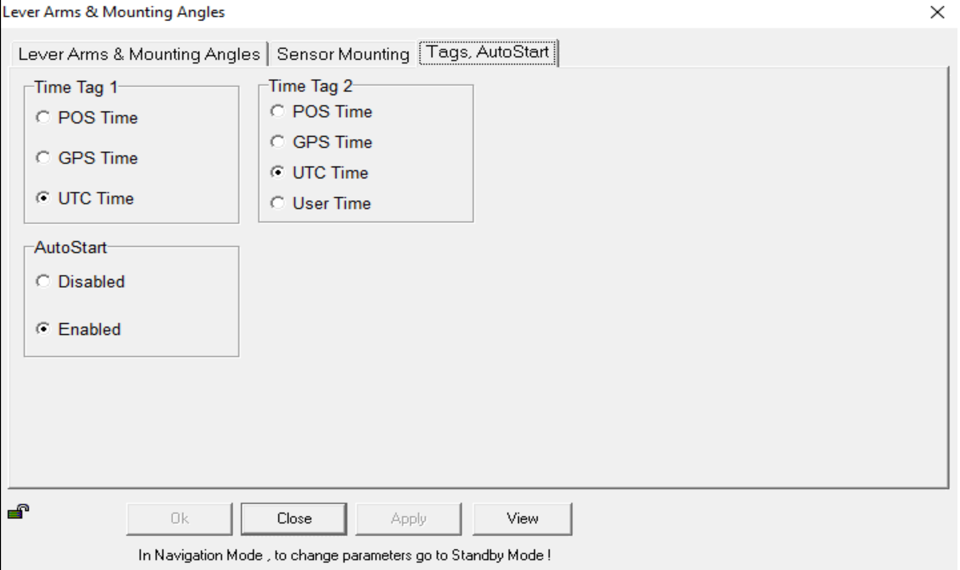
PPS Out – Polarity: ● Positive Pulse ○ Negative Pulse ○ Pass through

Pulse Width (msec) 1

Installation (Use Settings > Installation)

Installation opens another menu

Tags, Multipath and Auto Start (Use Settings > Installation > Tags, Multipath and Auto Start)



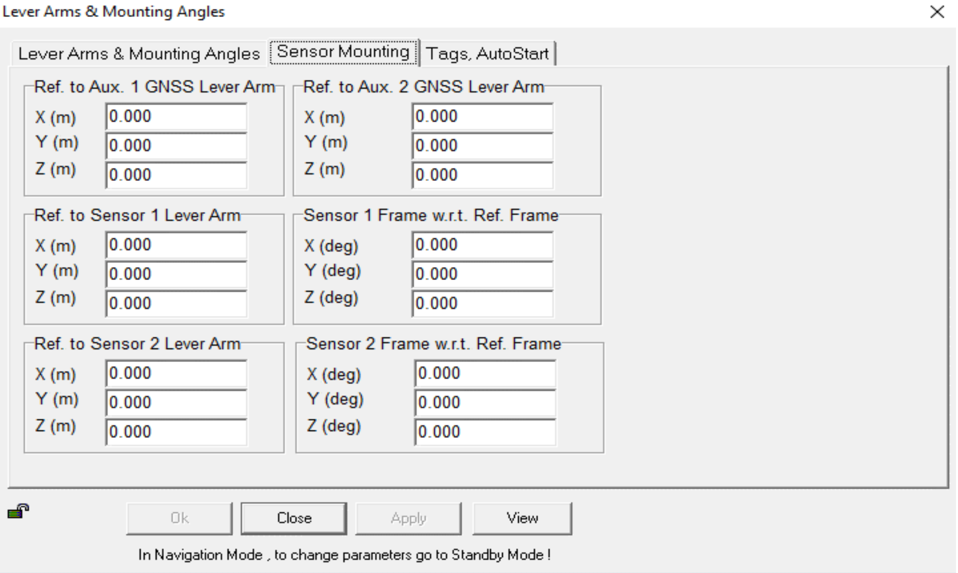
Time Tag 1
- ○ POS Time
- ○ GPS Time
- ● UTC Time

Time Tag 2
- ○ POS Time
- ○ GPS Time
- ● UTC Time
- ○ User Time

AutoStart
- ○ Disabled
- ● Enabled

In Navigation Mode , to change parameters go to Standby Mode !

Sensor Mounting (Use Settings > Installation > Sensor Mounting)



Ref. to Aux. 1 GNSS Lever Arm
X (m) 0.000
Y (m) 0.000
Z (m) 0.000

Ref. to Aux. 2 GNSS Lever Arm
X (m) 0.000
Y (m) 0.000
Z (m) 0.000

Ref. to Sensor 1 Lever Arm
X (m) 0.000
Y (m) 0.000
Z (m) 0.000

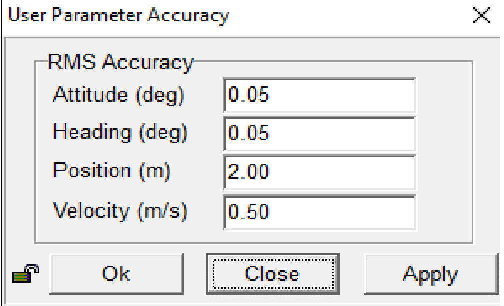
Sensor 1 Frame w.r.t. Ref. Frame
X (deg) 0.000
Y (deg) 0.000
Z (deg) 0.000

Ref. to Sensor 2 Lever Arm
X (m) 0.000
Y (m) 0.000
Z (m) 0.000

Sensor 2 Frame w.r.t. Ref. Frame
X (deg) 0.000
Y (deg) 0.000
Z (deg) 0.000

In Navigation Mode , to change parameters go to Standby Mode !

User Parameter Accuracy (Use Settings > Installation > User Accuracy)


User Parameter Accuracy

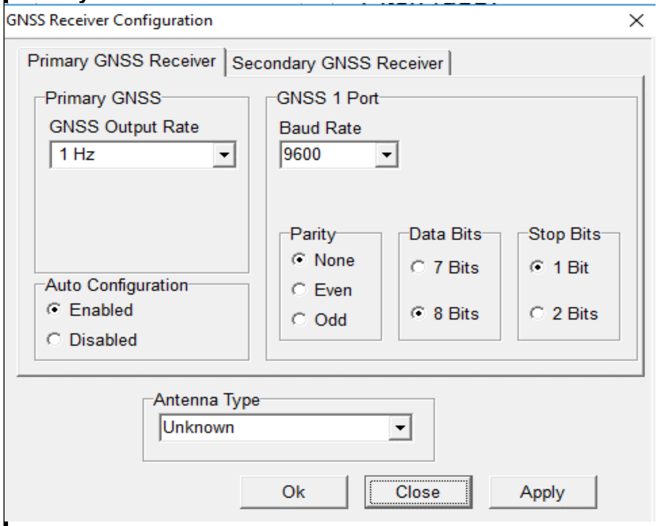
RMS Accuracy
Attitude (deg) 0.05
Heading (deg) 0.05
Position (m) 2.00
Velocity (m/s) 0.50

Frame Control (Use Tools > Config)

NOT ON THE VERSION 5

GPS Receiver Configuration (Use Settings> Installation> GPS Receiver Configuration)

Primary GPS Receiver


GNSS Receiver Configuration

Primary GNSS
GNSS Output Rate: 1 Hz

Auto Configuration
● Enabled
○ Disabled

GNSS 1 Port
Baud Rate: 9600

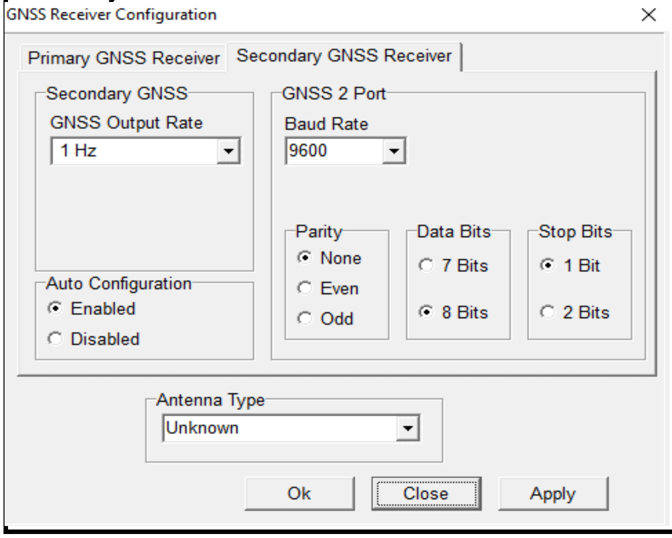
Parity
● None
○ Even
○ Odd

Data Bits
○ 7 Bits
● 8 Bits

Stop Bits
● 1 Bit
○ 2 Bits

Antenna Type: Unknown

Secondary GPS Receiver


GNSS Receiver Configuration

Secondary GNSS
GNSS Output Rate: 1 Hz

Auto Configuration
● Enabled
○ Disabled

GNSS 2 Port
Baud Rate: 9600

Parity
● None
○ Even
○ Odd

Data Bits
○ 7 Bits
● 8 Bits

Stop Bits
● 1 Bit
○ 2 Bits

Antenna Type: Unknown

POS/MV Calibration Report

Field Unit: Thomas Jefferson

SYSTEM INFORMATION

Vessel: TJ2903

Date: 7/15/2019 **Dn:** 196

Personnel: Broztek, Cziraki, Arboleda

PCS Serial #

IP Address: 129.100.001.231

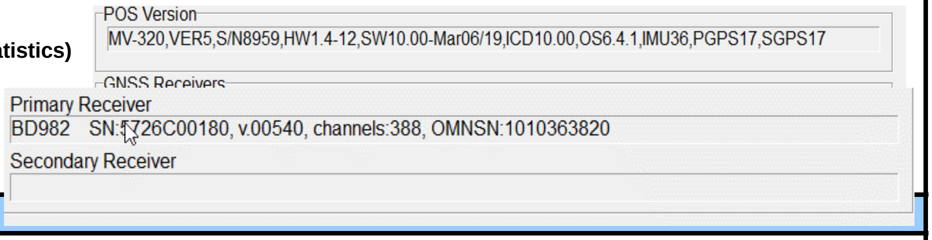
POS controller Version (Use Menu Help > About) 10

POS Version (Use Menu View > Statistics)

GPS Receivers

Primary Receiver

Secondary Receiver



POS Version
MV-320,VER5,S/N8959,HW1.4-12,SW10.00-Mar06/19,ICD10.00,OS6.4.1,IMU36,PGPS17,SGPS17

GNSS Receivers

Primary Receiver
BD982 SN:5726C00180, v.00540, channels:388, OMNSN:1010363820

Secondary Receiver

CALIBRATION AREA

Location: Lambert Bend, Elizabeth River

Approximate Position:

	D	M	S
Lat	36	51	78
Lon	76	19	17

DGPS Beacon Station: 138

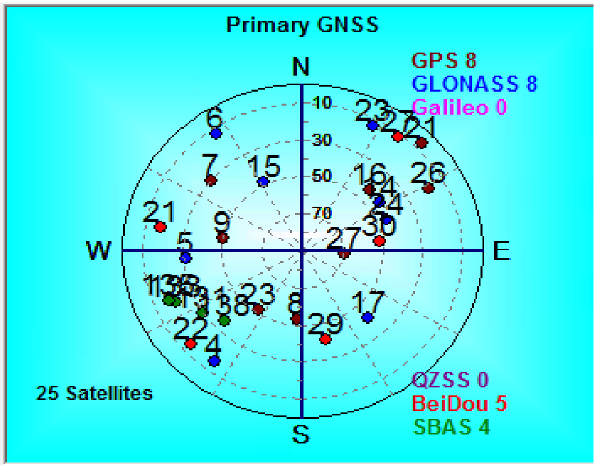
Frequency:

Satellite Constellation

(Use View> GPS Data)

Primary GPS (Port Antenna)

N



HDOP: 0.716

VDOP: 1.06

Sattelites in Use: 21

PDOP 1.100 (Use View> GAMS Solution)

Note:

POS/MV CONFIGURATION

Settings

Gams Parameter Setup (Use Settings > Installation > GAMS Intallation)

User Entries, Pre-Calibration

	Two Antenna Separation (m)
0.50	Heading Calibration Threshold
0	Heading Correction

Baseline Vector

-0.007	X Component (m)
1.435	YComponent (m)
-0.049	Z Component (m)

Configuration Notes:

POS/MV CALIBRATION

Calibration Procedure:

(Refer to POS MV V3 Installation and Operation Guide, 4-25)

Start time: 0630

End time: 0700

Heading accuracy achieved for calibration: 0.032

Calibration Results:

Gams Parameter Setup (Use Settings > Installation > GAMS Intallation)

POS/MV Post-Calibration Values

1.465	Two Antenna Separation (m)
0.500	Heading Calibration Threshold
0	Heading Correction

Baseline Vector

-0.006	X Component (m)
1.46	YComponent (m)
-0.003	Z Component (m)

GAMS Status Online? yes

Save Settings? yes

Calibration Notes:

Save POS Settings on PC (Use File > Store POS Settings on PC)

File Name: 2903_D196_postGAMS_071519

GENERAL GUIDANCE

The POS/MV uses a Right-Hand Orthogonal Reference System

The right-hand orthogonal system defines the following:

- The x-axis is in the fore-aft direction in the appropriate reference frame.
- The y-axis is perpendicular to the x-axis and points towards the right (starboard) side in the appropriate reference frame.
- The z-axis points downwards in the appropriate reference frame.

The POS/MV uses a Tate-Bryant Rotation Sequence

Apply the rotation in the following order to bring the two frames of reference into complete alignment:

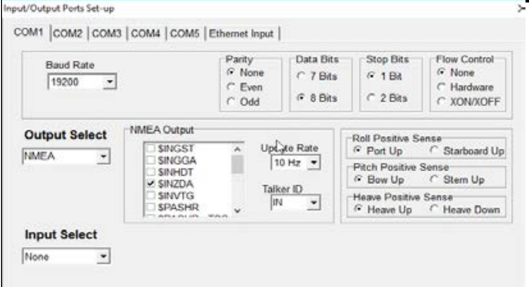
a) Heading rotation - apply a right-hand screw rotation θz about the z-axis to align one frame with the other.

b) Pitch rotation - apply a right-hand screw rotation θy about the once-rotated y-axis to align one frame with the other.

c) Roll rotation - apply a right-hand screw rotation θx about the twice-rotated x-axis to align one frame with the other.

SETTINGS (insert screen grabs)

Input/Output Ports (Use Settings > Input/Output Ports)



Input/Output Ports Set-up

COM1 | COM2 | COM3 | COM4 | COM5 | Ethernet Input

Baud Rate: 19200

Parity: ● None ○ Even ○ Odd

Data Bits: ○ 7 Bits ● 8 Bits

Stop Bits: ● 1 Bit ○ 2 Bits

Flow Control: ● None ○ Hardware ○ XON/XOFF

Output Select: NMEA

NMEA Output: ☐ $INGST ☐ $INGGA ☐ $INHDT ☑ $INZDA ☐ $INVTG ☐ $PASHR

Update Rate: 10 Hz

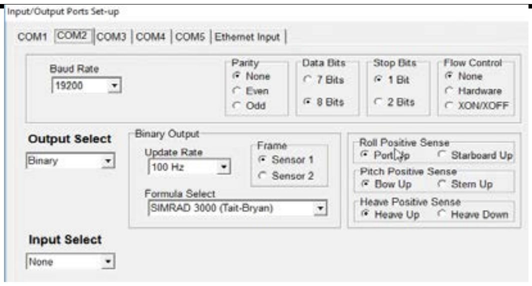
Talker ID: IN

Roll Positive Sense: ● Port Up ○ Starboard Up

Pitch Positive Sense: ● Bow Up ○ Stern Up

Heave Positive Sense: ● Heave Up ○ Heave Down

Input Select: None



Input/Output Ports Set-up

COM1 | COM2 | COM3 | COM4 | COM5 | Ethernet Input

Baud Rate: 19200

Parity: ● None ○ Even ○ Odd

Data Bits: ○ 7 Bits ● 8 Bits

Stop Bits: ● 1 Bit ○ 2 Bits

Flow Control: ● None ○ Hardware ○ XON/XOFF

Output Select: Binary

Binary Output

Update Rate: 100 Hz

Frame: ● Sensor 1 ○ Sensor 2

Formula Select: SIMRAD 3000 (Tait-Bryan)

Roll Positive Sense: ● Port Up ○ Starboard Up

Pitch Positive Sense: ● Bow Up ○ Stern Up

Heave Positive Sense: ● Heave Up ○ Heave Down

Input Select: None

Input/Output Ports Set-up

COM1 | COM2 | COM3 | COM4 | COM5 | Ethernet Input

Baud Rate: 4800

Interface: ● RS232 ○ RS422

Parity: ● None ○ Even ○ Odd

Data Bits: ○ 7 Bits ● 8 Bits

Stop Bits: ● 1 Bit ○ 2 Bits

Flow Control: ● None ○ Hardware ○ XON/XOFF

Output Select: NMEA

NMEA Output: ☐ $INGST ☐ $INGGA ☐ $INHDT ☐ $INZDA ☐ $INVTG ☐ $PASHR

Update Rate: 2 Hz

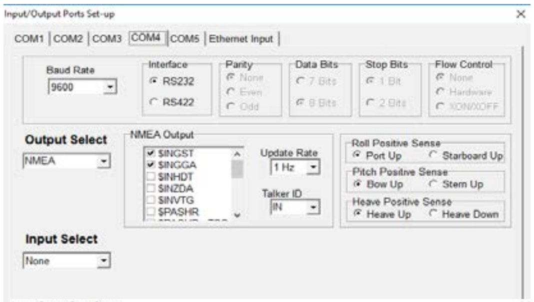
Talker ID: IN

Roll Positive Sense: ● Port Up ○ Starboard Up

Pitch Positive Sense: ● Bow Up ○ Stern Up

Heave Positive Sense: ● Heave Up ○ Heave Down

Input Select: None



Input/Output Ports Set-up

COM1 | COM2 | COM3 | COM4 | COM5 | Ethernet Input

Baud Rate: 9600

Interface: ● RS232 ○ RS422

Parity: ● None ○ Even ○ Odd

Data Bits: ○ 7 Bits ● 8 Bits

Stop Bits: ● 1 Bit ○ 2 Bits

Flow Control: ● None ○ Hardware ○ XON/XOFF

Output Select: NMEA

NMEA Output: ☑ $INGST ☑ $INGGA ☐ $INHDT ☐ $INZDA ☐ $INVTG ☐ $PASHR

Update Rate: 1 Hz

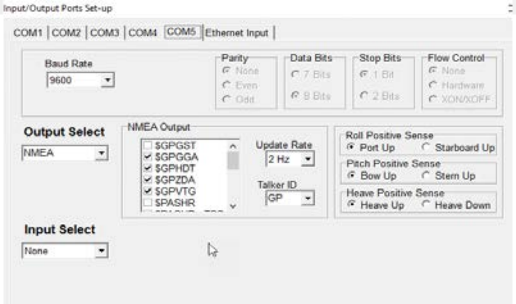
Talker ID: IN

Roll Positive Sense: ● Port Up ○ Starboard Up

Pitch Positive Sense: ● Bow Up ○ Stern Up

Heave Positive Sense: ● Heave Up ○ Heave Down

Input Select: None



Input/Output Ports Set-up

COM1 | COM2 | COM3 | COM4 | COM5 | Ethernet Input

Baud Rate: 9600

Parity: ● None ○ Even ○ Odd

Data Bits: ○ 7 Bits ● 8 Bits

Stop Bits: ● 1 Bit ○ 2 Bits

Flow Control: ● None ○ Hardware ○ XON/XOFF

Output Select: NMEA

NMEA Output: ☐ $GPGST ☑ $GPGGA ☑ $GPHDT ☑ $GPZDA ☑ $GPVTG ☐ $PASHR

Update Rate: 2 Hz

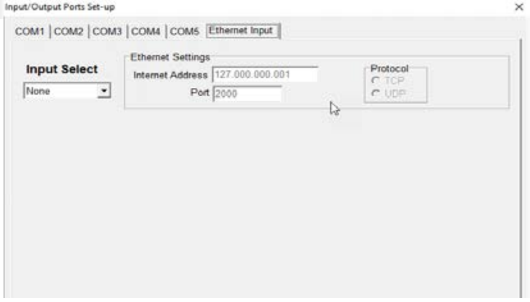
Talker ID: GP

Roll Positive Sense: ● Port Up ○ Starboard Up

Pitch Positive Sense: ● Bow Up ○ Stern Up

Heave Positive Sense: ● Heave Up ○ Heave Down

Input Select: None



Input/Output Ports Set-up

COM1 | COM2 | COM3 | COM4 | COM5 | Ethernet Input

Input Select: None

Ethernet Settings

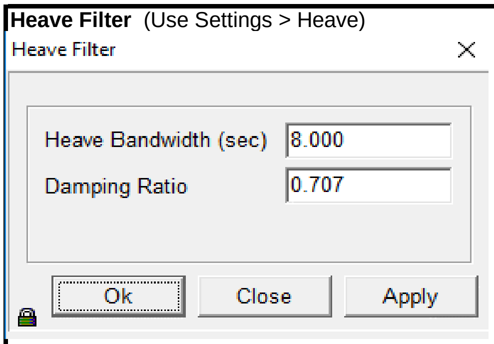
Internet Address: 127.000.000.001

Port: 2000

Protocol: ○ TCP ○ UDP

NOTE:

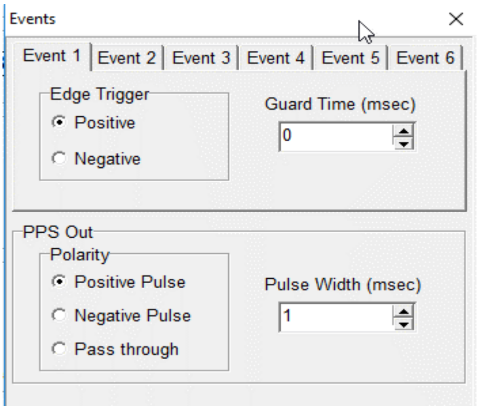
Heave Filter (Use Settings > Heave)



Heave Bandwidth (sec) 8.000

Damping Ratio 0.707

Events (Use Settings > Events)



Edge Trigger
- ● Positive
- ○ Negative

Guard Time (msec) 0

PPS Out

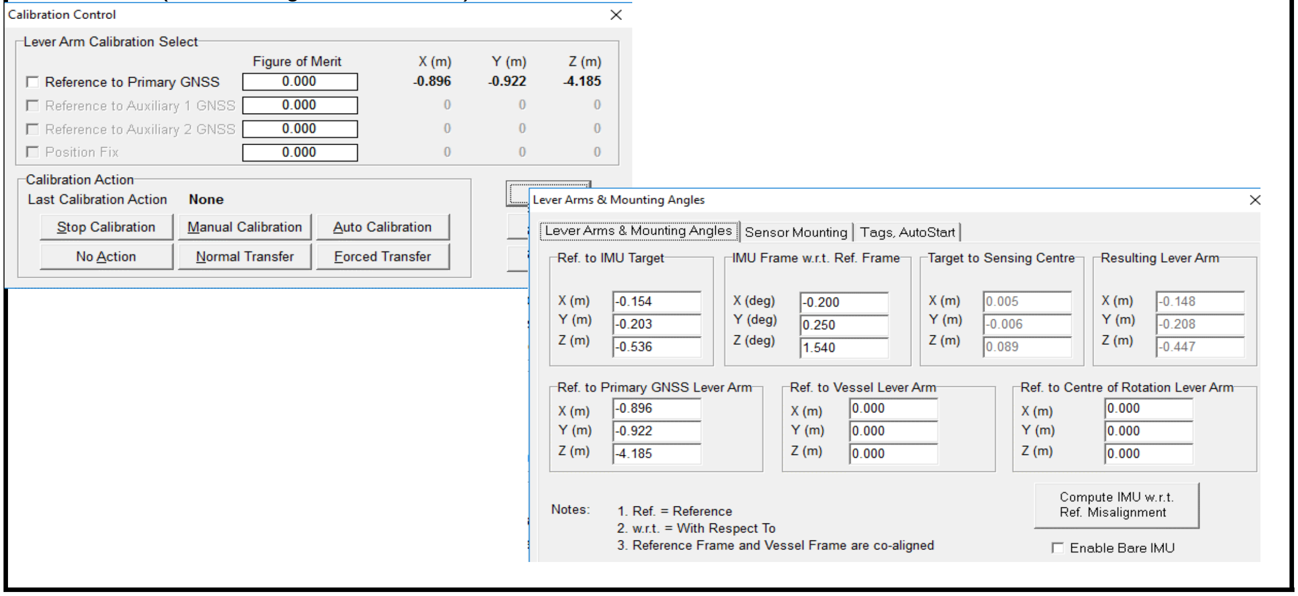
Polarity
- ● Positive Pulse
- ○ Negative Pulse
- ○ Pass through

Pulse Width (msec) 1

Time Sync (Use Settings > Time Sync)

NOT ON THE VERSION 4

Installation (Use Settings > Installation)



Lever Arm Calibration Select

	Figure of Merit	X (m)	Y (m)	Z (m)
☐ Reference to Primary GNSS	0.000	-0.896	-0.922	-4.185
☐ Reference to Auxiliary 1 GNSS	0.000	0	0	0
☐ Reference to Auxiliary 2 GNSS	0.000	0	0	0
☐ Position Fix	0.000	0	0	0

Calibration Action

Last Calibration Action **None**

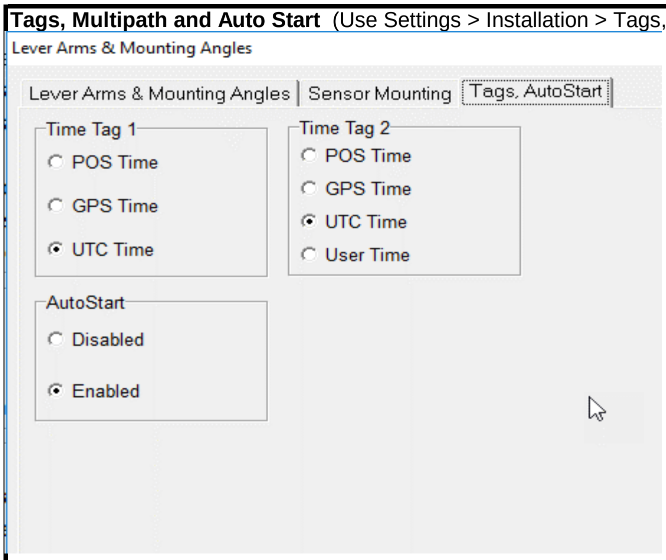
	Ref. to IMU Target		IMU Frame w.r.t. Ref. Frame		Target to Sensing Centre		Resulting Lever Arm
X (m)	-0.154	X (deg)	-0.200	X (m)	0.005	X (m)	-0.148
Y (m)	-0.203	Y (deg)	0.250	Y (m)	-0.006	Y (m)	-0.208
Z (m)	-0.536	Z (deg)	1.540	Z (m)	0.089	Z (m)	-0.447

	Ref. to Primary GNSS Lever Arm		Ref. to Vessel Lever Arm		Ref. to Centre of Rotation Lever Arm
X (m)	-0.896	X (m)	0.000	X (m)	0.000
Y (m)	-0.922	Y (m)	0.000	Y (m)	0.000
Z (m)	-4.185	Z (m)	0.000	Z (m)	0.000

Notes:
1. Ref. = Reference
2. w.r.t. = With Respect To
3. Reference Frame and Vessel Frame are co-aligned

☐ Enable Bare IMU

Tags, Multipath and Auto Start (Use Settings > Installation > Tags, Multipath and Auto Start)



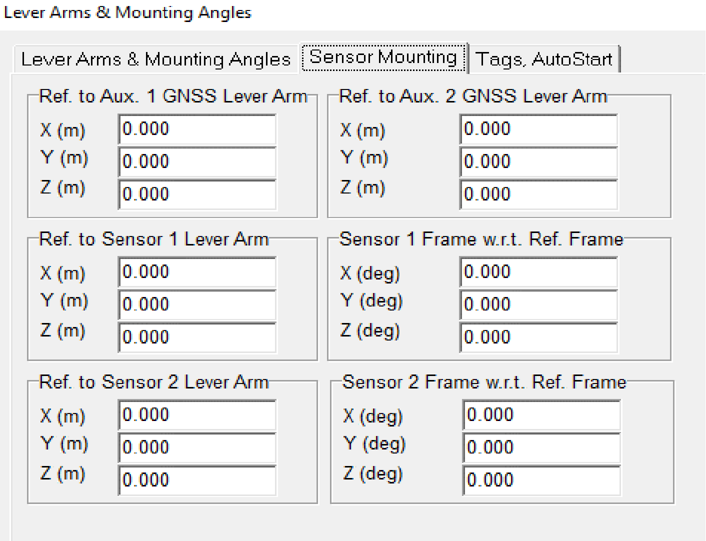
Lever Arms & Mounting Angles

Time Tag 1
- ○ POS Time
- ○ GPS Time
- ● UTC Time

Time Tag 2
- ○ POS Time
- ○ GPS Time
- ● UTC Time
- ○ User Time

AutoStart
- ○ Disabled
- ● Enabled

Sensor Mounting (Use Settings > Installation > Sensor Mounting)



Lever Arms & Mounting Angles

Ref. to Aux. 1 GNSS Lever Arm
X (m) 0.000
Y (m) 0.000
Z (m) 0.000

Ref. to Aux. 2 GNSS Lever Arm
X (m) 0.000
Y (m) 0.000
Z (m) 0.000

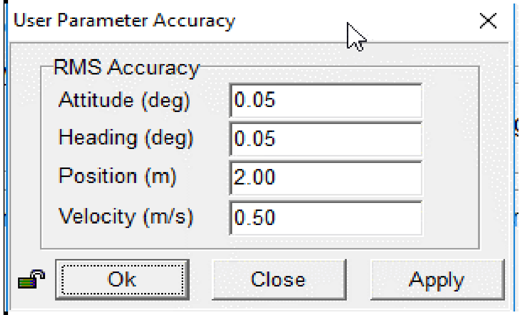
Ref. to Sensor 1 Lever Arm
X (m) 0.000
Y (m) 0.000
Z (m) 0.000

Sensor 1 Frame w.r.t. Ref. Frame
X (deg) 0.000
Y (deg) 0.000
Z (deg) 0.000

Ref. to Sensor 2 Lever Arm
X (m) 0.000
Y (m) 0.000
Z (m) 0.000

Sensor 2 Frame w.r.t. Ref. Frame
X (deg) 0.000
Y (deg) 0.000
Z (deg) 0.000

User Parameter Accuracy (Use Settings > Installation > User Accuracy)


User Parameter Accuracy

RMS Accuracy

Attitude (deg) 0.05

Heading (deg) 0.05

Position (m) 2.00

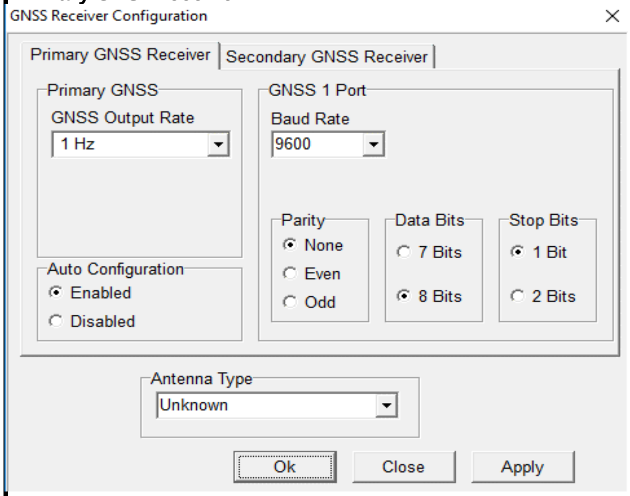
Velocity (m/s) 0.50

Frame Control (Use Tools > Config)

NOT ON THE VERSION 4

GPS Receiver Configuration (Use Settings> Installation> GPS Receiver Configuration)

Primary GPS Receiver


GNSS Receiver Configuration

Primary GNSS

GNSS Output Rate: 1 Hz

Auto Configuration: ● Enabled ○ Disabled

GNSS 1 Port

Baud Rate: 9600

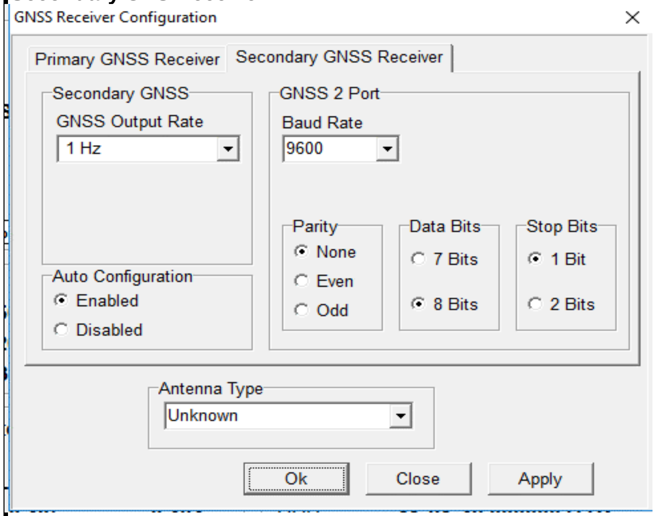
Parity: ● None ○ Even ○ Odd

Data Bits: ○ 7 Bits ● 8 Bits

Stop Bits: ● 1 Bit ○ 2 Bits

Antenna Type: Unknown

Secondary GPS Receiver


GNSS Receiver Configuration

Secondary GNSS

GNSS Output Rate: 1 Hz

Auto Configuration: ● Enabled ○ Disabled

GNSS 2 Port

Baud Rate: 9600

Parity: ● None ○ Even ○ Odd

Data Bits: ○ 7 Bits ● 8 Bits

Stop Bits: ● 1 Bit ○ 2 Bits

Antenna Type: Unknown

POS/MV Calibration Report

Field Unit: Thomas Jefferson

SYSTEM INFORMATION

Vessel: TJ2904

Date: 7/9/2019 **Dn:** 190

Personnel: Brown, Grains, Faha,

PCS Serial #

IP Address: 129.100.1.231

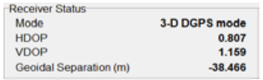
POS controller Version (Use Menu Help > About) 10

POS Version (Use Menu View > Statistics) MV-320 Version 5

GPS Receivers

Primary Receiver

Secondary Receiver



Receiver Status

Mode	3-D DGPS mode
HDOP	0.807
VDOP	1.159
Geoidal Separation (m)	-38.466

Receiver Status

Mode	3-D DGPS mode
HDOP	0.806
VDOP	1.160
Geoidal Separation (m)	-38.463

CALIBRATION AREA

Location: Lamberts Point

Approximate Position:

	D	M	S
Lat	36	51	46.85
Lon	76	19	14.9

DGPS Beacon Station:

Frequency:

Satellite Constellation

(Use View> GPS Data)

Primary GPS (Port Antenna)

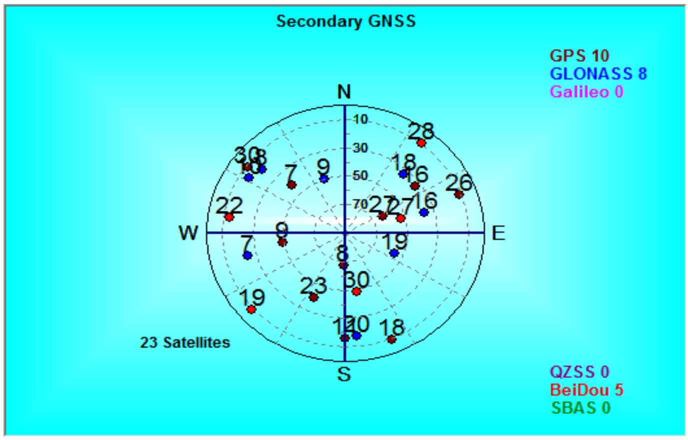
N

HDOP: 0.738

VDOP: 1.11

Sattelites in Use: 22

PDOP 1.100 (Use View> GAMS Solution)



Note:

POS/MV CONFIGURATION

Settings

Gams Parameter Setup (Use Settings > Installation > GAMS Intallation)

User Entries, Pre-Calibration		Baseline Vector	
1.489	Two Antenna Separation (m)	**0.004**	X Component (m)
	Heading Calibration Threshold	**1.488**	YComponent (m)
	Heading Correction	**0**	Z Component (m)

Configuration Notes:

POS/MV CALIBRATION

Calibration Procedure:

(Refer to POS MV V3 Installation and Operation Guide, 4-25)

Start time: 1132

End time: 1141

Heading accuracy achieved for calibration: 0.028

Calibration Results:

Gams Parameter Setup (Use Settings > Installation > GAMS Intallation)

POS/MV Post-Calibration Values		Baseline Vector	
	Two Antenna Separation (m)	**0.005**	X Component (m)
	Heading Calibration Threshold	**1.484**	YComponent (m)
	Heading Correction	**0.018**	Z Component (m)

GAMS Status Online? yes

Save Settings? yes

Calibration Notes: used forced calibration

Save POS Settings on PC (Use File > Store POS Settings on PC)

File Name: 2904_20190709.nvm

GENERAL GUIDANCE

The POS/MV uses a Right-Hand Orthogonal Reference System

The right-hand orthogonal system defines the following:

- The x-axis is in the fore-aft direction in the appropriate reference frame.
- The y-axis is perpendicular to the x-axis and points towards the right (starboard) side in the appropriate reference frame.
- The z-axis points downwards in the appropriate reference frame.

The POS/MV uses a Tate-Bryant Rotation Sequence

Apply the rotation in the following order to bring the two frames of reference into complete alignment:

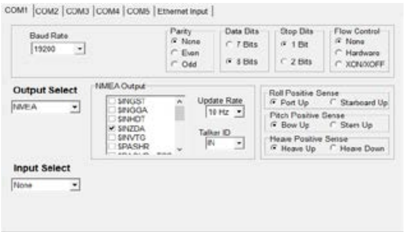
a) Heading rotation - apply a right-hand screw rotation θz about the z-axis to align one frame with the other.

b) Pitch rotation - apply a right-hand screw rotation θy about the once-rotated y-axis to align one frame with the other.

c) Roll rotation - apply a right-hand screw rotation θx about the twice-rotated x-axis to align one frame with the other.

SETTINGS (insert screen grabs)

Input/Output Ports (Use Settings > Input/Output Ports)



Baud Rate: 19200

Parity: ● None ○ Even ○ Odd

Data Bits: ○ 7 Bits ● 8 Bits

Stop Bits: ● 1 Bit ○ 2 Bits

Flow Control: ● None ○ Hardware ○ XON/XOFF

Output Select: NMEA

NMEA Output: ☐ $INGST ☐ $INGGA ☐ $INHDT ☑ $INZDA ☐ $INVTG ☐ $PASHR

Update Rate: 10 Hz

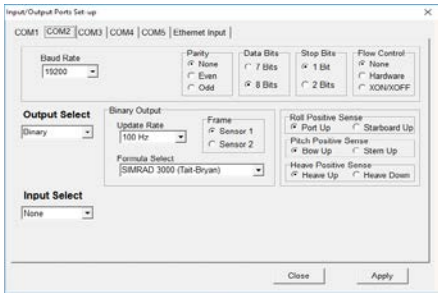
Talker ID: IN

Roll Positive Sense: ● Port Up ○ Starboard Up

Pitch Positive Sense: ● Bow Up ○ Stern Up

Heave Positive Sense: ● Heave Up ○ Heave Down

Input Select: None



Baud Rate: 19200

Parity: ● None ○ Even ○ Odd

Data Bits: ○ 7 Bits ● 8 Bits

Stop Bits: ● 1 Bit ○ 2 Bits

Flow Control: ● None ○ Hardware ○ XON/XOFF

Output Select: Binary

Binary Output — Update Rate: 100 Hz

Frame: ● Sensor 1 ○ Sensor 2

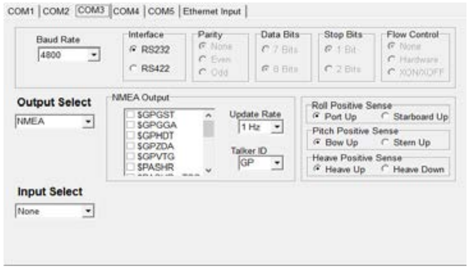
Formula Select: SIMRAD 3000 (Tait-Bryan)

Roll Positive Sense: ● Port Up ○ Starboard Up

Pitch Positive Sense: ● Bow Up ○ Stern Up

Heave Positive Sense: ● Heave Up ○ Heave Down

Input Select: None



Baud Rate: 4800

Interface: ● RS232 ○ RS422

Parity: ● None ○ Even ○ Odd

Data Bits: ○ 7 Bits ● 8 Bits

Stop Bits: ● 1 Bit ○ 2 Bits

Flow Control: ● None ○ Hardware ○ XON/XOFF

Output Select: NMEA

NMEA Output: ☐ $GPGST ☐ $GPGGA ☐ $GPHDT ☐ $GPZDA ☐ $GPVTG ☐ $PASHR

Update Rate: 1 Hz

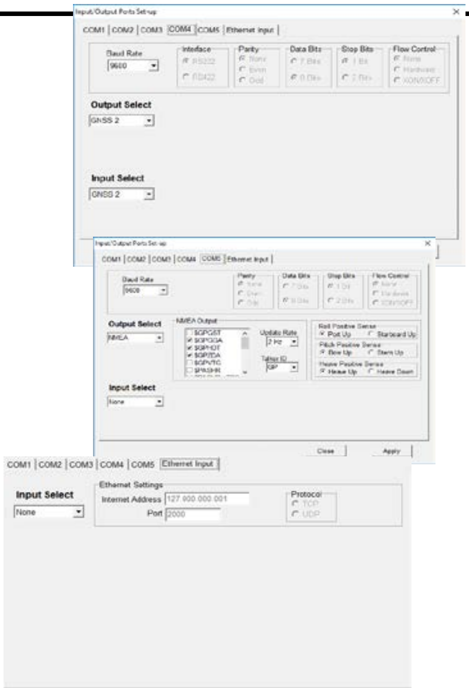
Talker ID: GP

Roll Positive Sense: ● Port Up ○ Starboard Up

Pitch Positive Sense: ● Bow Up ○ Stern Up

Heave Positive Sense: ● Heave Up ○ Heave Down

Input Select: None



COM4 — Baud Rate: 9600

Interface: ● RS232 ○ RS422

Parity: ● None ○ Even ○ Odd

Data Bits: ○ 7 Bits ● 8 Bits

Stop Bits: ● 1 Bit ○ 2 Bits

Flow Control: ● None ○ Hardware ○ XON/XOFF

Output Select: GNSS 2

Input Select: GNSS 2

COM5 — Baud Rate: 9600

Parity: ● None ○ Even ○ Odd

Data Bits: ○ 7 Bits ● 8 Bits

Stop Bits: ● 1 Bit ○ 2 Bits

Flow Control: ● None ○ Hardware ○ XON/XOFF

Output Select: NMEA

NMEA Output: ☐ $GPGST ☑ $GPGGA ☑ $GPHDT ☑ $GPZDA ☐ $GPVTG ☐ $PASHR

Update Rate: 2 Hz

Talker ID: GP

Roll Positive Sense: ● Port Up ○ Starboard Up

Pitch Positive Sense: ● Bow Up ○ Stern Up

Heave Positive Sense: ● Heave Up ○ Heave Down

Input Select: None

Ethernet Input — Input Select: None

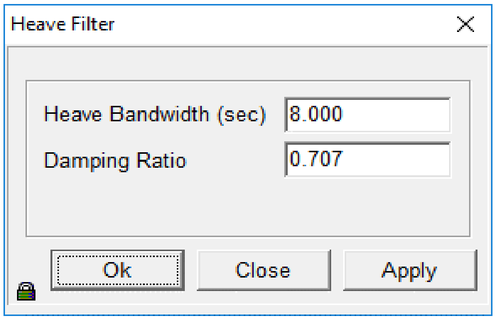
Ethernet Settings — Internet Address: 127.000.000.001

Port: 2000

Protocol: ○ TCP ○ UDP

NOTE:

Heave Filter (Use Settings > Heave)



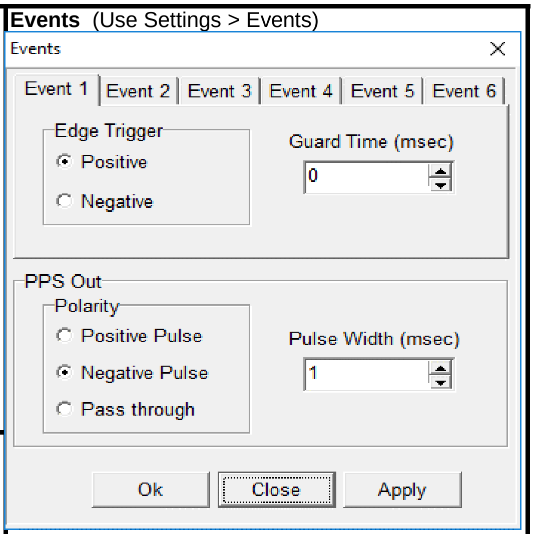
Heave Bandwidth (sec) 8.000

Damping Ratio 0.707

Time Sync (Use Settings > Time Sync)

NOT ON THE VERSION 4

Events (Use Settings > Events)



Edge Trigger

● Positive

○ Negative

Guard Time (msec) 0

PPS Out

Polarity

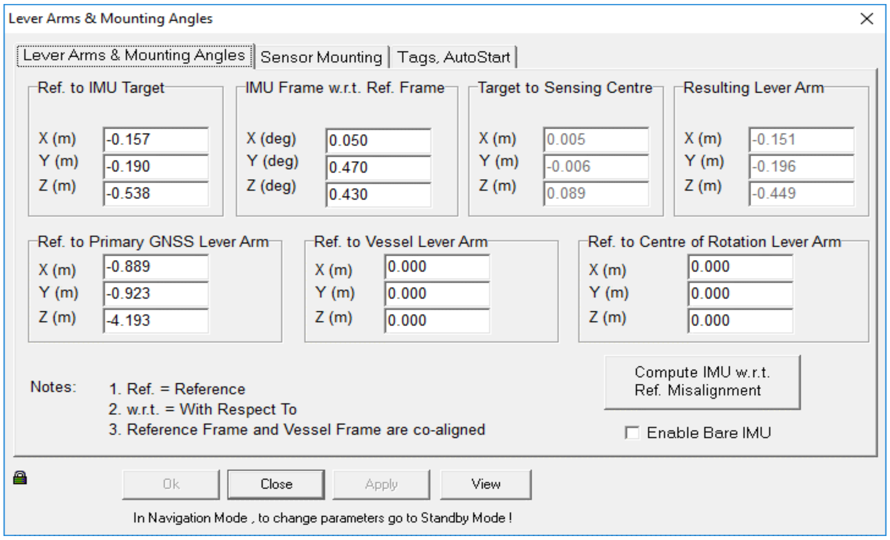
○ Positive Pulse

● Negative Pulse

○ Pass through

Pulse Width (msec) 1

Installation (Use Settings > Installation)



Ref. to IMU Target

X (m) -0.157

Y (m) -0.190

Z (m) -0.538

IMU Frame w.r.t. Ref. Frame

X (deg) 0.050

Y (deg) 0.470

Z (deg) 0.430

Target to Sensing Centre

X (m) 0.005

Y (m) -0.006

Z (m) 0.089

Resulting Lever Arm

X (m) -0.151

Y (m) -0.196

Z (m) -0.449

Ref. to Primary GNSS Lever Arm

X (m) -0.889

Y (m) -0.923

Z (m) -4.193

Ref. to Vessel Lever Arm

X (m) 0.000

Y (m) 0.000

Z (m) 0.000

Ref. to Centre of Rotation Lever Arm

X (m) 0.000

Y (m) 0.000

Z (m) 0.000

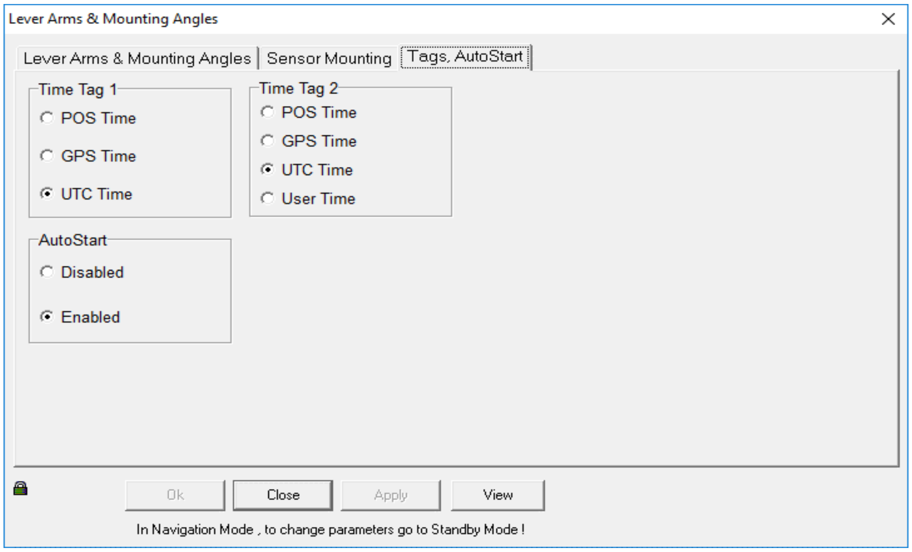
Notes:

1. Ref. = Reference
2. w.r.t. = With Respect To
3. Reference Frame and Vessel Frame are co-aligned

☐ Enable Bare IMU

In Navigation Mode , to change parameters go to Standby Mode !

Tags, Multipath and Auto Start (Use Settings > Installation > Tags, Multipath and Auto Start)



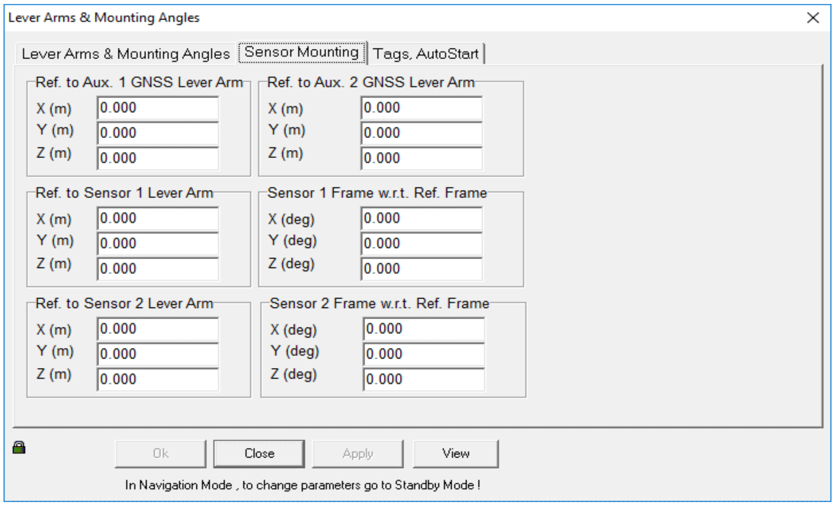
Time Tag 1
- ○ POS Time
- ○ GPS Time
- ● UTC Time

Time Tag 2
- ○ POS Time
- ○ GPS Time
- ● UTC Time
- ○ User Time

AutoStart
- ○ Disabled
- ● Enabled

In Navigation Mode , to change parameters go to Standby Mode !

Sensor Mounting (Use Settings > Installation > Sensor Mounting)



Ref. to Aux. 1 GNSS Lever Arm
X (m) 0.000
Y (m) 0.000
Z (m) 0.000

Ref. to Aux. 2 GNSS Lever Arm
X (m) 0.000
Y (m) 0.000
Z (m) 0.000

Ref. to Sensor 1 Lever Arm
X (m) 0.000
Y (m) 0.000
Z (m) 0.000

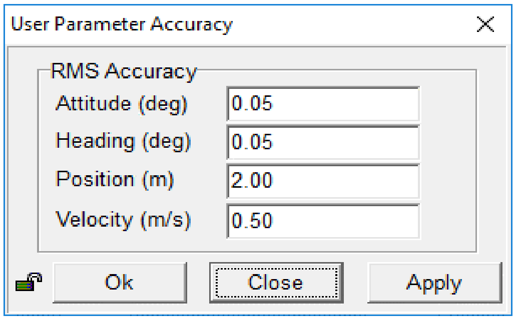
Sensor 1 Frame w.r.t. Ref. Frame
X (deg) 0.000
Y (deg) 0.000
Z (deg) 0.000

Ref. to Sensor 2 Lever Arm
X (m) 0.000
Y (m) 0.000
Z (m) 0.000

Sensor 2 Frame w.r.t. Ref. Frame
X (deg) 0.000
Y (deg) 0.000
Z (deg) 0.000

In Navigation Mode , to change parameters go to Standby Mode !

User Parameter Accuracy (Use Settings > Installation > User Accuracy)



RMS Accuracy

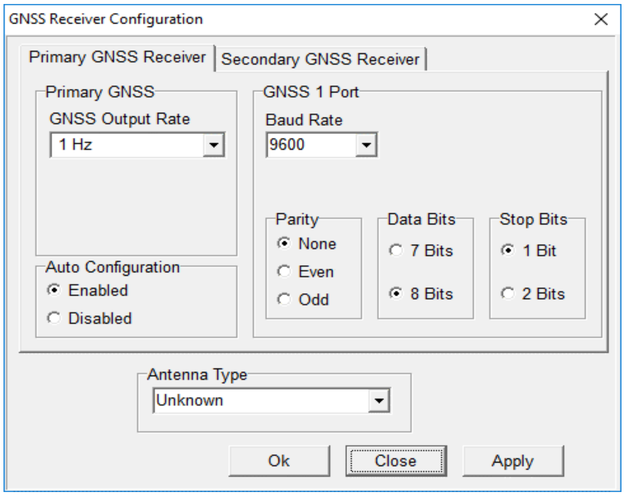
Attitude (deg): 0.05
Heading (deg): 0.05
Position (m): 2.00
Velocity (m/s): 0.50

Frame Control (Use Tools > Config)

NOT ON THE VERSION 4

GPS Receiver Configuration (Use Settings> Installation> GPS Receiver Configuration)

Primary GPS Receiver



Primary GNSS
GNSS Output Rate: 1 Hz

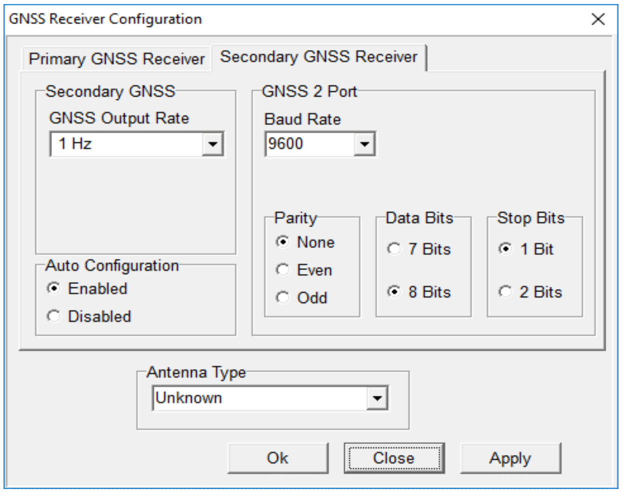
Auto Configuration: ● Enabled ○ Disabled

GNSS 1 Port
Baud Rate: 9600

Parity: ● None ○ Even ○ Odd
Data Bits: ○ 7 Bits ● 8 Bits
Stop Bits: ● 1 Bit ○ 2 Bits

Antenna Type: Unknown

Secondary GPS Receiver



Secondary GNSS
GNSS Output Rate: 1 Hz

Auto Configuration: ● Enabled ○ Disabled

GNSS 2 Port
Baud Rate: 9600

Parity: ● None ○ Even ○ Odd
Data Bits: ○ 7 Bits ● 8 Bits
Stop Bits: ● 1 Bit ○ 2 Bits

Antenna Type: Unknown

POS/MV Calibration Report

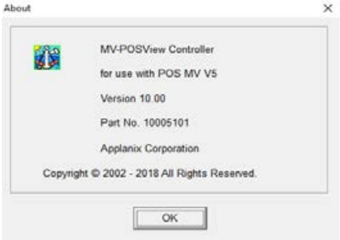
Field Unit: Thomas Jefferson

SYSTEM INFORMATION

Vessel: 2904

Date: 7/15/2019 **Dn:** 196

Personnel: Brown, Bayliss, Arboleda


About
MV-POSView Controller
for use with POS MV V5
Version 10.00
Part No. 10005101
Applanix Corporation
Copyright © 2002 - 2018 All Rights Reserved.

PCS Serial #

IP Address: 129.100.001.231

POS controller Version (Use Menu Help > About)

POS Version (Use Menu View > Statistics) MV-320 Version 5

GPS Receivers

Primary Receiver

Secondary Receiver

CALIBRATION AREA

Location: Craney Island

Approximate Position:

	D	M	S
Lat	36	55	54.809
Lon	76	21	58.602

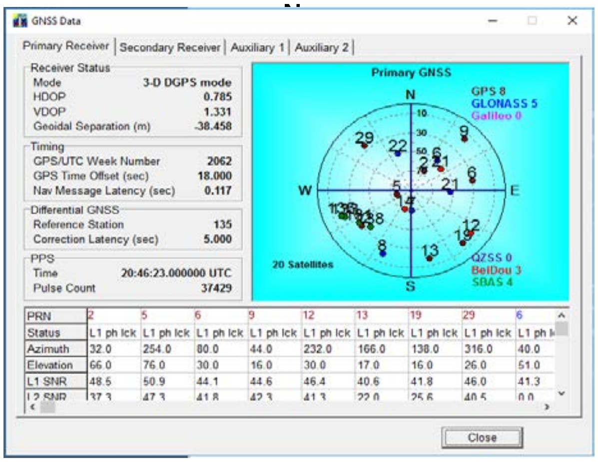
DGPS Beacon Station:

Frequency:

Satellite Constellation

(Use View> GPS Data)

Primary GPS (Port Antenna)


GNSS Data

Primary Receiver | Secondary Receiver | Auxiliary 1 | Auxiliary 2

Receiver Status
Mode 3-D DGPS mode
HDOP 0.785
VDOP 1.331
Geoidal Separation (m) -38.458

Timing
GPS/UTC Week Number 2062
GPS Time Offset (sec) 18.000
Nav Message Latency (sec) 0.117

Differential GNSS
Reference Station 135
Correction Latency (sec) 5.000

PPS
Time 20:46:23.000000 UTC
Pulse Count 37429

PRN	2	5	6	9	12	13	19	29	6
Status	L1 ph lck	L1 ph lck	L1 ph lck	L1 ph lck	L1 ph lck	L1 ph lck	L1 ph lck	L1 ph lck	L1 ph l
Azimuth	32.0	254.0	80.0	44.0	232.0	166.0	138.0	316.0	40.0
Elevation	66.0	76.0	30.0	16.0	30.0	17.0	16.0	26.0	51.0
L1 SNR	48.5	50.9	44.1	44.6	46.4	40.6	41.8	46.0	41.3
L2 SNR	37.3	47.3	41.8	42.3	41.3	22.0	25.6	40.5	0.0

HDOP: 0.925

VDOP: 1.359

Sattelites in Use: 29

PDOP 1.300 (Use View> GAMS Solution)

Note: Did not get a screen shot of the GNSS Data at time of acq.

POS/MV CONFIGURATION

Settings

Gams Parameter Setup (Use Settings > Installation > GAMS Intallation)

User Entries, Pre-Calibration

1.487	Two Antenna Separation (m)
0.50	Heading Calibration Threshold
0	Heading Correction

Baseline Vector

-0.002	X Component (m)
1.485	YComponent (m)
0	Z Component (m)

Configuration Notes:

POS/MV CALIBRATION

Calibration Procedure:

(Refer to POS MV V3 Installation and Operation Guide, 4-25)

Start time: 1740

End time: 1750

Heading accuracy achieved for calibration: 0.022m

Calibration Results:

Gams Parameter Setup (Use Settings > Installation > GAMS Intallation)

POS/MV Post-Calibration Values

1.487	Two Antenna Separation (m)
0.500	Heading Calibration Threshold
0	Heading Correction

Baseline Vector

-0.002	X Component (m)
1.485	YComponent (m)
0	Z Component (m)

GAMS Status Online? yes

Save Settings? yes

Calibration Notes: used forced calibration

Save POS Settings on PC (Use File > Store POS Settings on PC)

File Name: ____

GENERAL GUIDANCE

The POS/MV uses a Right-Hand Orthogonal Reference System

The right-hand orthogonal system defines the following:

- The x-axis is in the fore-aft direction in the appropriate reference frame.
- The y-axis is perpendicular to the x-axis and points towards the right (starboard) side in the appropriate reference frame.
- The z-axis points downwards in the appropriate reference frame.

The POS/MV uses a Tate-Bryant Rotation Sequence

Apply the rotation in the following order to bring the two frames of reference into complete alignment:

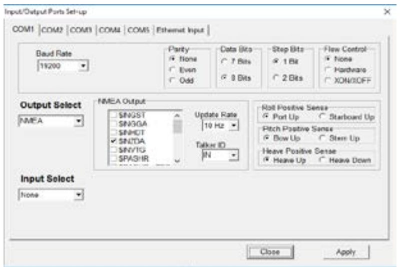
a) Heading rotation - apply a right-hand screw rotation θz about the z-axis to align one frame with the other.

b) Pitch rotation - apply a right-hand screw rotation θy about the once-rotated y-axis to align one frame with the other.

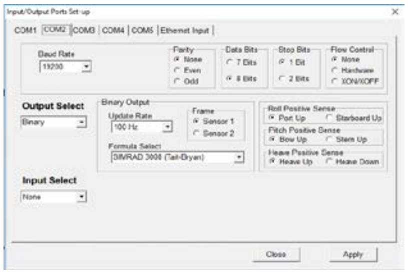
c) Roll rotation - apply a right-hand screw rotation θx about the twice-rotated x-axis to align one frame with the other.

SETTINGS (insert screen grabs)

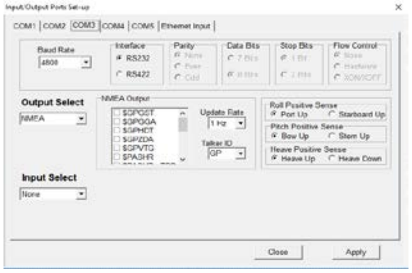
Input/Output Ports (Use Settings > Input/Output Ports)



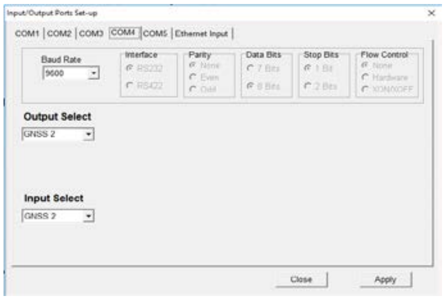
Baud Rate: 19200
Parity: ● None ○ Even ○ Odd
Data Bits: ○ 7 Bits ● 8 Bits
Stop Bits: ● 1 Bit ○ 2 Bits
Flow Control: ● None ○ Hardware ○ XON/XOFF
Output Select: NMEA
NMEA Output: ☐ $INGST ☐ $INGGA ☐ $INHDT ☑ $INZDA ☐ $INVTG ☐ $PASHR
Update Rate: 10 Hz
Talker ID: IN
Roll Positive Sense: ● Port Up ○ Starboard Up
Pitch Positive Sense: ● Bow Up ○ Stern Up
Heave Positive Sense: ● Heave Up ○ Heave Down
Input Select: None



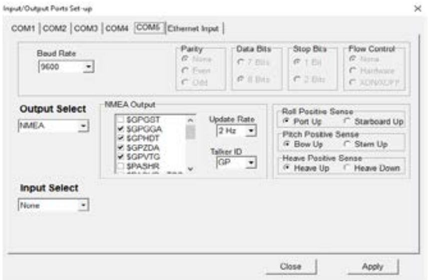
Baud Rate: 19200
Parity: ● None ○ Even ○ Odd
Data Bits: ○ 7 Bits ● 8 Bits
Stop Bits: ● 1 Bit ○ 2 Bits
Flow Control: ● None ○ Hardware ○ XON/XOFF
Output Select: Binary
Binary Output
Update Rate: 100 Hz
Frame: ● Sensor 1 ○ Sensor 2
Formula Select: SIMRAD 3000 (Tait-Bryan)
Roll Positive Sense: ● Port Up ○ Starboard Up
Pitch Positive Sense: ● Bow Up ○ Stern Up
Heave Positive Sense: ● Heave Up ○ Heave Down
Input Select: None



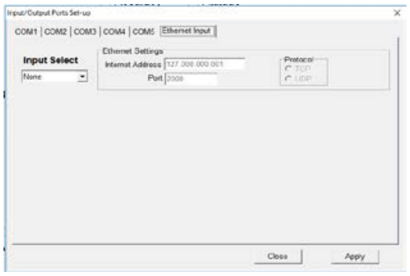
Baud Rate: 4800
Interface: ● RS232 ○ RS422
Parity: ● None ○ Even ○ Odd
Data Bits: ○ 7 Bits ● 8 Bits
Stop Bits: ● 1 Bit ○ 2 Bits
Flow Control: ● None ○ Hardware ○ XON/XOFF
Output Select: NMEA
NMEA Output: ☐ $GPGST ☐ $GPGGA ☐ $GPHDT ☐ $GPZDA ☐ $GPVTG ☐ $PASHR
Update Rate: 1 Hz
Talker ID: GP
Roll Positive Sense: ● Port Up ○ Starboard Up
Pitch Positive Sense: ● Bow Up ○ Stern Up
Heave Positive Sense: ● Heave Up ○ Heave Down
Input Select: None



Baud Rate: 9600
Interface: ● RS232 ○ RS422
Parity: ● None ○ Even ○ Odd
Data Bits: ○ 7 Bits ● 8 Bits
Stop Bits: ● 1 Bit ○ 2 Bits
Flow Control: ● None ○ Hardware ○ XON/XOFF
Output Select: GNSS 2
Input Select: GNSS 2



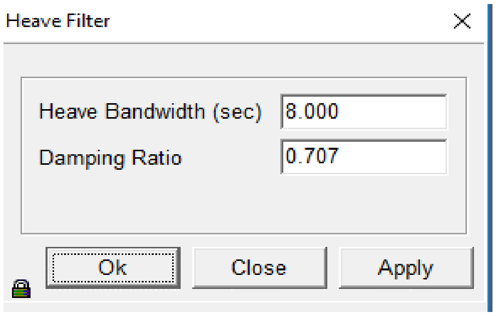
Baud Rate: 9600
Parity: ● None ○ Even ○ Odd
Data Bits: ○ 7 Bits ● 8 Bits
Stop Bits: ● 1 Bit ○ 2 Bits
Flow Control: ● None ○ Hardware ○ XON/XOFF
Output Select: NMEA
NMEA Output: ☐ $GPGST ☑ $GPGGA ☑ $GPHDT ☑ $GPZDA ☑ $GPVTG ☐ $PASHR
Update Rate: 2 Hz
Talker ID: GP
Roll Positive Sense: ● Port Up ○ Starboard Up
Pitch Positive Sense: ● Bow Up ○ Stern Up
Heave Positive Sense: ● Heave Up ○ Heave Down
Input Select: None



Input Select: None
Ethernet Settings
Internet Address: 127.000.000.001
Port: 2008
Protocol: ○ TCP ○ UDP

NOTE:

Heave Filter (Use Settings > Heave)



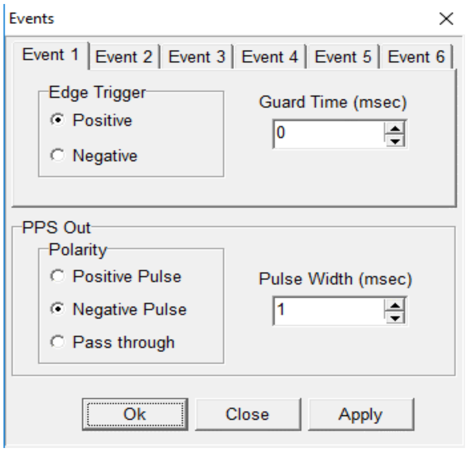
Heave Bandwidth (sec) 8.000

Damping Ratio 0.707

Time Sync (Use Settings > Time Sync)

NOT ON THE VERSION 4

Events (Use Settings > Events)



Edge Trigger
- ● Positive
- ○ Negative

Guard Time (msec) 0

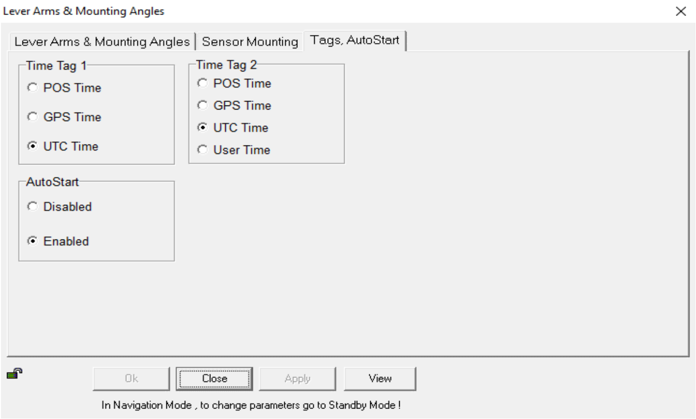
PPS Out

Polarity
- ○ Positive Pulse
- ● Negative Pulse
- ○ Pass through

Pulse Width (msec) 1

Installation (Use Settings > Installation)

Tags, Multipath and Auto Start (Use Settings > Installation > Tags, Multipath and Auto Start)



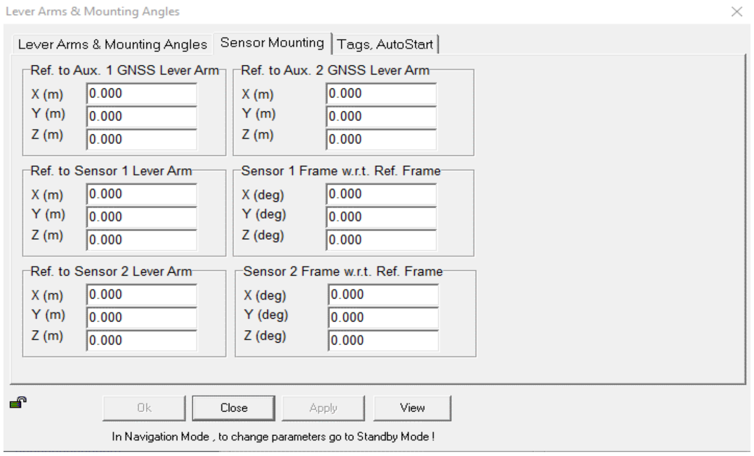
Time Tag 1
○ POS Time
○ GPS Time
● UTC Time

Time Tag 2
○ POS Time
○ GPS Time
● UTC Time
○ User Time

AutoStart
○ Disabled
● Enabled

In Navigation Mode , to change parameters go to Standby Mode !

Sensor Mounting (Use Settings > Installation > Sensor Mounting)



Ref. to Aux. 1 GNSS Lever Arm
X (m) 0.000
Y (m) 0.000
Z (m) 0.000

Ref. to Aux. 2 GNSS Lever Arm
X (m) 0.000
Y (m) 0.000
Z (m) 0.000

Ref. to Sensor 1 Lever Arm
X (m) 0.000
Y (m) 0.000
Z (m) 0.000

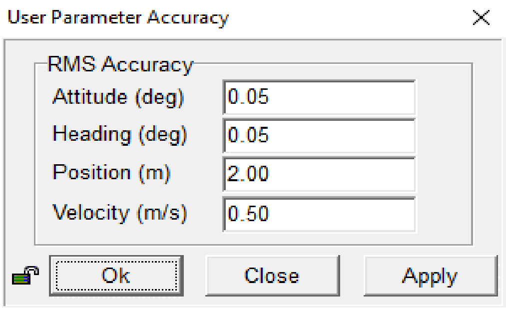
Sensor 1 Frame w.r.t. Ref. Frame
X (deg) 0.000
Y (deg) 0.000
Z (deg) 0.000

Ref. to Sensor 2 Lever Arm
X (m) 0.000
Y (m) 0.000
Z (m) 0.000

Sensor 2 Frame w.r.t. Ref. Frame
X (deg) 0.000
Y (deg) 0.000
Z (deg) 0.000

In Navigation Mode , to change parameters go to Standby Mode !

User Parameter Accuracy (Use Settings > Installation > User Accuracy)



User Parameter Accuracy

RMS Accuracy

Attitude (deg) 0.05

Heading (deg) 0.05

Position (m) 2.00

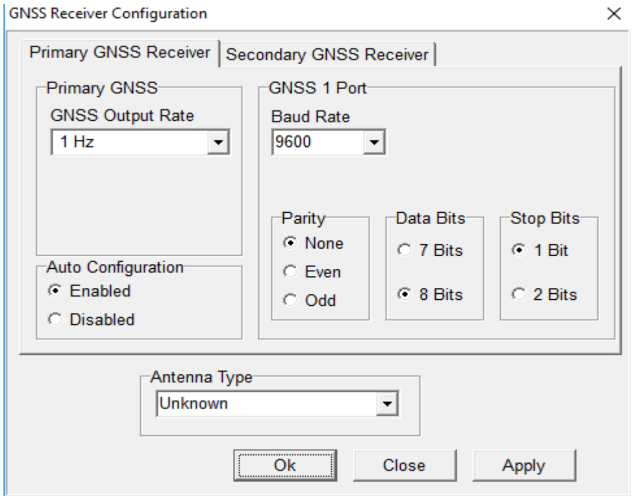
Velocity (m/s) 0.50

Frame Control (Use Tools > Config)

NOT ON THE VERSION 4

GPS Receiver Configuration (Use Settings> Installation> GPS Receiver Configuration)

Primary GPS Receiver



GNSS Receiver Configuration

Primary GNSS

GNSS Output Rate: 1 Hz

Auto Configuration: ● Enabled ○ Disabled

GNSS 1 Port

Baud Rate: 9600

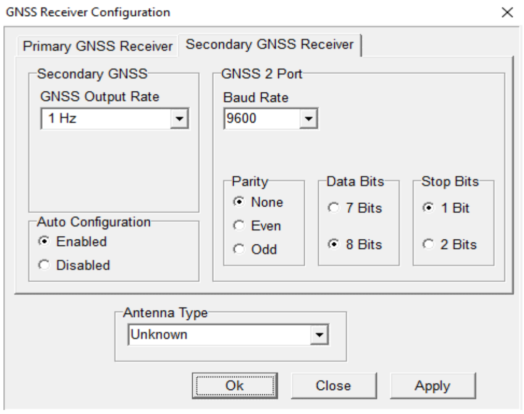
Parity: ● None ○ Even ○ Odd

Data Bits: ○ 7 Bits ● 8 Bits

Stop Bits: ● 1 Bit ○ 2 Bits

Antenna Type: Unknown

Secondary GPS Receiver



GNSS Receiver Configuration

Secondary GNSS

GNSS Output Rate: 1 Hz

Auto Configuration: ● Enabled ○ Disabled

GNSS 2 Port

Baud Rate: 9600

Parity: ● None ○ Even ○ Odd

Data Bits: ○ 7 Bits ● 8 Bits

Stop Bits: ● 1 Bit ○ 2 Bits

Antenna Type: Unknown

Due to applying patch test values within POSview at acquisition and setting the reference point as the transducer, Lever arms are calibrated post processed within POSPAC MMS 8.4.

Lever arm values are as follows for OPR-E350-TJ-19:

2903:

DN 189-195		
IMU Lever Arm	GNSS Lever Arm	GAMS
X= -0.148	X= -0.896	X= -0.007
Y= -0.208	Y= -0.922	Y= 1.435
Z= -0.447	Z= -4.185	Z= -0.049

DN 196-217		
IMU Lever Arm	GNSS Lever Arm	GAMS
X= -0.148	X= -0.896	X= -0.006
Y= -0.208	Y= -0.922	Y= 1.460
Z= -0.447	Z= -4.185	Z= -0.003

DN 219-220		
IMU Lever Arm	GNSS Lever Arm	GAMS
X= -0.148	X= -0.896	X= -0.006
Y= -0.208	Y= -0.922	Y= 1.460
Z= -0.447	Z= -4.185	Z= -0.003

DN 338-340		
IMU Lever Arm	GNSS Lever Arm	GAMS
X= -0.160	X= -0.896	X= -0.030
Y= -0.236	Y= -0.922	Y= 1.462
Z= -0.406	Z= -4.185	Z= -0.022

DN 350-355		
IMU Lever Arm	GNSS Lever Arm	GAMS
X= -0.160	X= -0.896	X= 0.010
Y= -0.236	Y= -0.922	Y= 1.460
Z= -0.406	Z= -4.185	Z= -0.008

2904:

DN 189-196		
IMU Lever Arm	GNSS Lever Arm	GAMS
X= -0.151	X= -0.889	X= 0.004
Y= -0.196	Y= -0.923	Y= 1.488
Z= -0.449	Z= -4.193	Z= 0.000

DN 197-203		
IMU Lever Arm	GNSS Lever Arm	GAMS
X= -0.151	X= -0.889	X= 0.004
Y= -0.196	Y= -0.923	Y= 1.488
Z= -0.449	Z= -4.193	Z= 0.000

DN 203-210/214-217

IMU Lever Arm	GNSS Lever Arm	GAMS
X= -0.151	X= -0.889	X= -0.002
Y= -0.196	Y= -0.923	Y= 1.485
Z= -0.449	Z= -4.193	Z= 0.000

DN 211

IMU Lever Arm	GNSS Lever Arm	GAMS
X= -0.151	X= -0.889	X= -0.002
Y= -0.196	Y= -0.923	Y= 1.485
Z= -0.449	Z= -4.193	Z= 0.000

DN 339-355

IMU Lever Arm	GNSS Lever Arm	GAMS
X= -0.151	X= -0.872	X= 0.003
Y= -0.196	Y= -0.896	Y= 1.485
Z= -0.449	Z= -4.261	Z= 0.000

Echosounder and Range Finder Patch Test Reports

Velodyne LiDAR VLP-16 Installation, Calibration, and Verification on Thomas Jefferson HSL 2903

07/01/2019

Installation

A special mounting arm for the VLP-16 LiDAR puck was constructed using ¼” stainless steel and was mounted to the top of the coxswain flat on the starboard side. The puck was mounted on the arm in the vertical orientation. Offsets for the mount’s center screw hole were measured from the BM STAR 3 benchmark which is located slightly inboard from the mounting arm (Figure 1). Calculations were then made to reference the center of the LiDAR puck to the vessel’s reference point (the center of the Kongsberg 2040 transducer face) using values found in the vessel survey report dated May 1, 2017 (Table 1). Offsets were measured in the forward (x) positive, starboard (y) positive, and down (z) positive directions. Final offset values were entered in to Hypack setup for the Velodyne LIDAR hardware driver. The Velodyne GPS receiver was installed on the top of the mounting arm to provide PPS timing for the system.

Figure 1: Installation of the Velodyne LiDAR VLP-16

	X (positive to bow)	Y (positive to stbd)	Z (positive downward)
From Transmitter (RP) to LiDAR	-2.143m	0.987m	-3.377m

Table 1: Velodyne LiDAR offset values

Calibration

A patch test calibration was performed on 06/10/2019 following the procedure outlined in the "LiDAR Patch Test Procedure" SOP dated 06/20/2019. The object used for the test was a large wooden platform with a cylindrical tank on top located in the vicinity of the Navy degaussing station near Lambert Bend on the Elizabeth River, VA (Figure 2). Hypack HYSWEEP Editor 64 bit was used to determine correctors for pitch, roll, and yaw. These values were then entered in to the Hypack hardware driver for data acquisition (Figure 3 and Table 2).

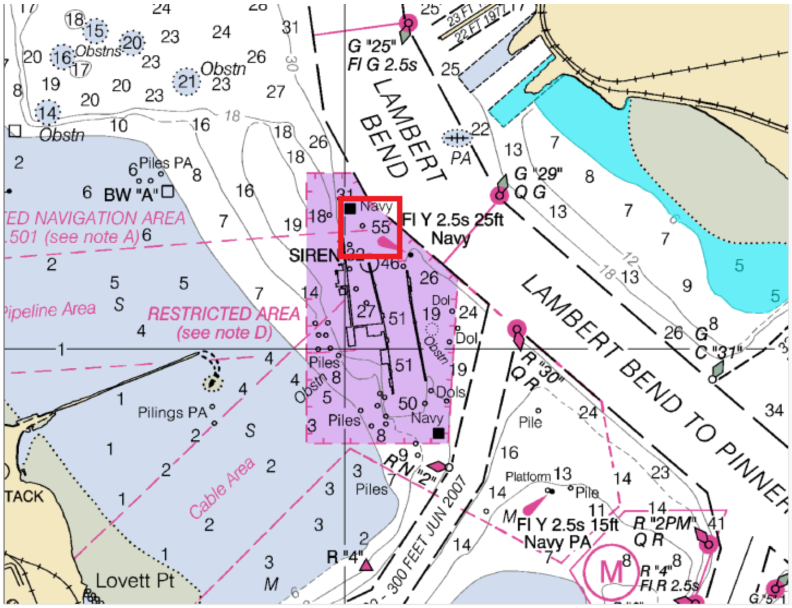


Figure 2: Patch test location for Velodyne LiDAR VLP-16 (red box)

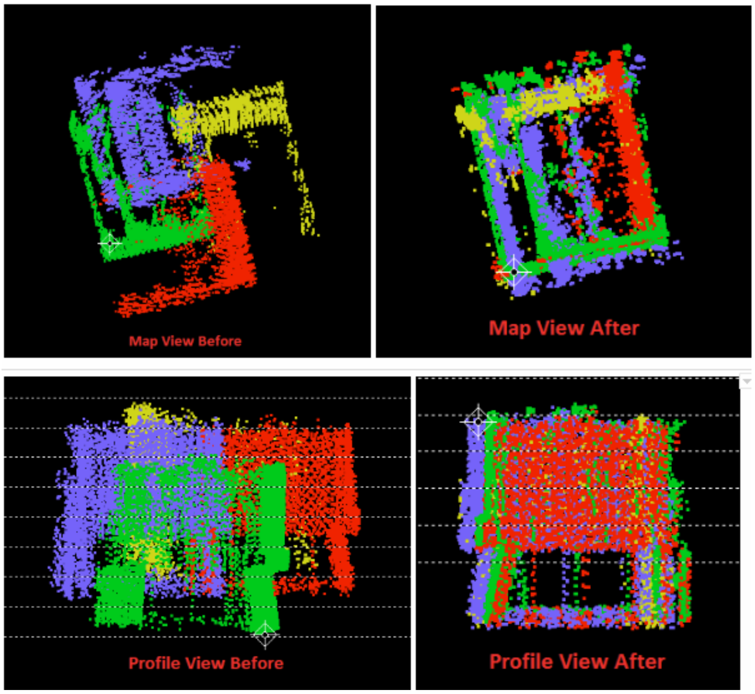


Figure 3: Patch test results as seen in HYSWEEP Editor

	Yaw	Pitch	Roll	Latency
Patch test values	2.65	-0.50	3.50	0.00

Table 2: Final patch test values

Kongsberg EM2040 Calibration and Verification on NOAA ship *Thomas Jefferson,* HSL 2904

09/26/2019

Calibration

Waterline measurements were made on both the port and starboard sides of HSL 2904 using benchmarks BM PORT 1 and BM STAR 1. An average of these values was used with the vertical transducer offset and vertical vessel survey values to calculate the static draft value for the transducer which was found to be +0.615m.

A patch test was conducted correctly on 9/26/2019 and performed according to guidance from FPM 2014. The patch test was performed over a wreck located north of Craney Island Disposal Area in Hampton Roads, VA at 36° 55'51.153, -76° 22' 45.9012. Thirteen lines were acquired for the patch test, although not all lines were used to identify biases. Line numbers 0000_20190926_135643_2903, 0001_20190926_140024_2903, 0002_20190926_140248_2903, 0003_20190926_140405_2903, 0007_20190926_141242_2903, 0009_20190926_141731_2903, and 0012_20190926_142133_2903 were used to correct for Time, Pitch, Roll, and Yaw biases.

Results of the patch tests can be found further in this DAPR.

A CTD cast was performed during acquisition of a reference surface in order to correct for sound speed differences during post processing. The planned line plan shown below (Figure 1). Location of collected lines of data may vary from planned lines.

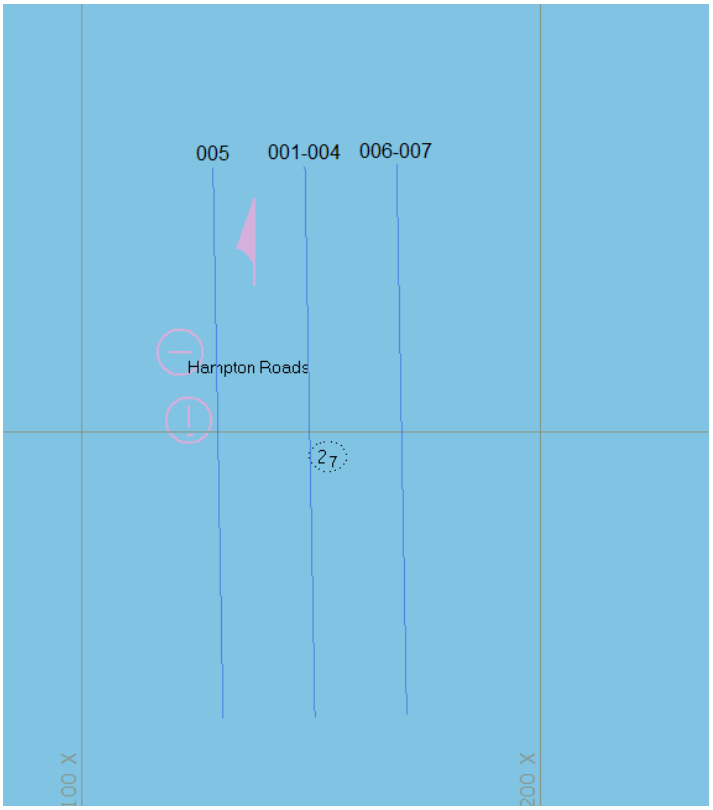


Figure 1: Planned lines over wreck for patch test conducted on 9/26/2019.

Verification

Data for a reference surface were collected on October 10, 2019 over a wreck located north of Craney Island Disposal Area in Hampton Roads, VA at 36° 55’51.153, -76° 22’ 45.9012. A CTD cast was performed prior to data collection in the near vicinity. Ten lines were collected over the wreck. Location of Reference surface can be seen below (Figure 2).

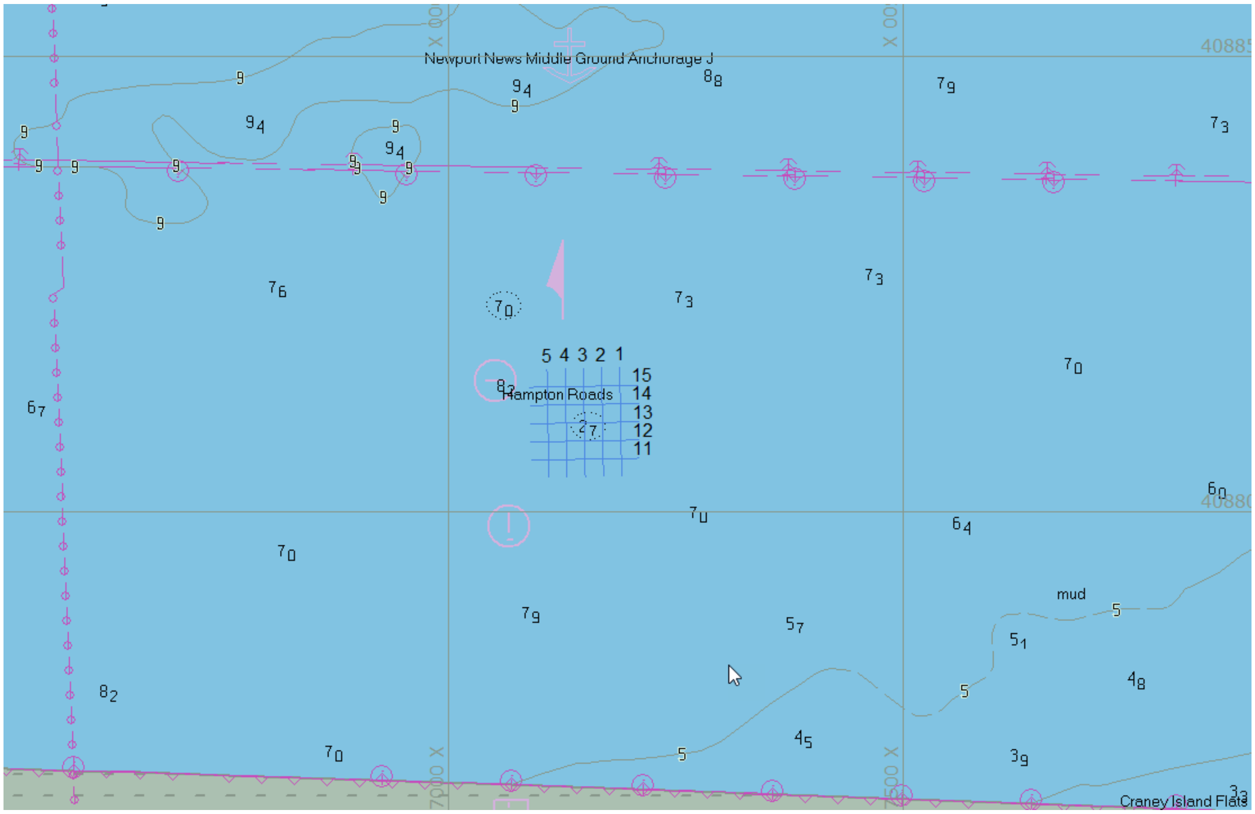
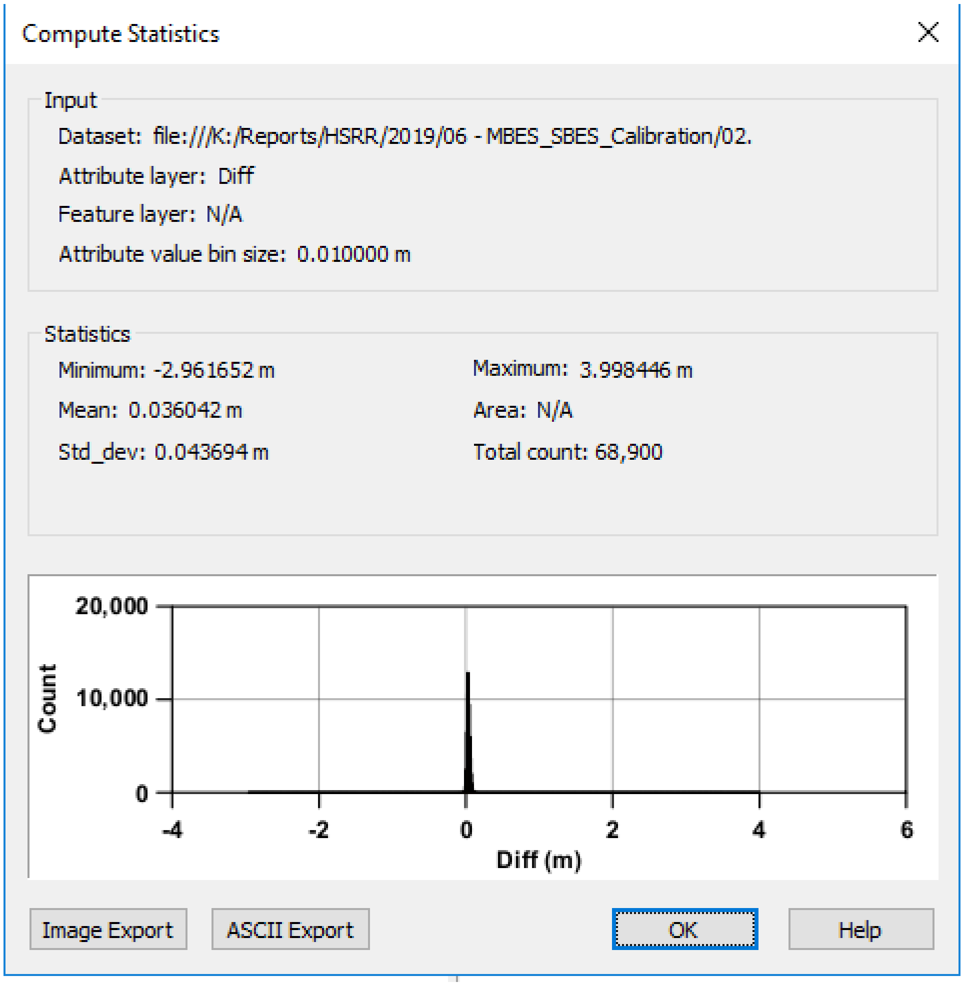


Figure 2: Location of MBES reference surface.

Results:

A roll offset of 0.07 was observed within the data of the reference surface and applied to the reference surface data via Caris HVF. This roll offset was added to the previous roll offset value and applied via Applanix POS for data collected going forward for field season 2019.



Compute Statistics

Input

Dataset: file:///K:/Reports/HSRR/2019/06 - MBES_SBES_Calibration/02.

Attribute layer: Diff

Feature layer: N/A

Attribute value bin size: 0.010000 m

Statistics

Minimum: -2.961652 m

Maximum: 3.998446 m

Mean: 0.036042 m

Area: N/A

Std_dev: 0.043694 m

Total count: 68,900

Figure 3: Difference surface statistics

Two Cube surfaces were created for the MBES. These surfaces were gridded at 50-centimeters for the 2040 MBES data. These two surfaces were then differenced. The results were a mean of 0.03 with a standard deviation of 0.04 (Figure 3).

Odom Echotrack CV200 Single Beam Installation, Calibration, and Verification on NOAA ship *Thomas Jefferson*, HSL 2903

06/06/2019

Installation

A ¼” stainless steel plate was constructed to allow the Echotrack CV200 transducer to be mounted on the hull of TJ HSL 2903 using the existing Kongsberg 2040 mounting box. The transducer was mounted in the fore-aft direction and offsets were measured from the center of the transducer face to benchmark KEEL BM FWD (Figure 1). Calculations were then made to reference the center of the transducer face to the vessel’s reference point (the center of the Kongsberg 2040 transducer face) using values found in the vessel survey report dated May 1, 2017 (Table 1). Offsets were measured in the forward (x) positive, starboard (y) positive, and down (z) positive directions. Final offset values were entered in to Hypack setup for the Echotrack single beam hardware driver.

Figure 1: Installation of transducer for Odom Echotrack CV200 on the hull of TJ HSL 2903.

	X (positive to bow)	Y (positive to stbd)	Z (positive to down)
From Transmitter (RP) to SBES	0.12625m	0.030925m	0.081m

Table 1: SBES transducer offset values.

Calibration

Waterline measurements were made on both the port and starboard sides of HSL 2903 using benchmarks BM PORT 1 and BM STAR 1. An average of these values was used with the vertical transducer offset and vertical vessel survey values to calculate the static draft value for the transducer which was found to be +0.704m. This value was entered in to the EChart bar check program for system calibration and was used during data collection for the reference surface. More accurate static draft measurements were taken after this bar check. The interaction of draft to index value located in the Echart software is unknown to survey. Water line value of +0.70 used for Field season 2019 in congruity with this bar check.

A bar check was performed according to guidance from the Bar Check Procedure SOP located on the TJ network and following the bar check dialog found in the EChart program provided with the Echotrack. A bar was constructed using a 10’ length of PVC pipe with a metal plate attached. Lines were attached at either end with marks at every meter (Figure 2). The bar check was performed alongside the small boat dock at MOC-A. The plate was positioned below the transducer and was lowered through depths of 2-5m. The Index Value was adjusted in the EChart bar check interface until the measured depth value of the system matched the known depth of the bar. The final Index Value was found to be 0.21. The sound speed value used for this check was 1500m/s per FPM 2014 1.5.4.

Results of the patch test can be found further in this DAPR.

A CTD cast was performed during acquisition of a reference surface in order to correct for sound speed differences during post processing per FPM 2014 1.5.4.

Figure 2: Bar used for bar check calibration.

Verification

Data for a reference surface were collected on June 5, 2019 over a wreck located north of Craney Island Disposal Area in Hampton Roads, VA at 36° 55’51.153, -76° 22’ 45.9012. A CTD cast was performed prior to data collection in the near vicinity. Ten lines were collected over the wreck with the settings seen below.

Frequency: 128kHz

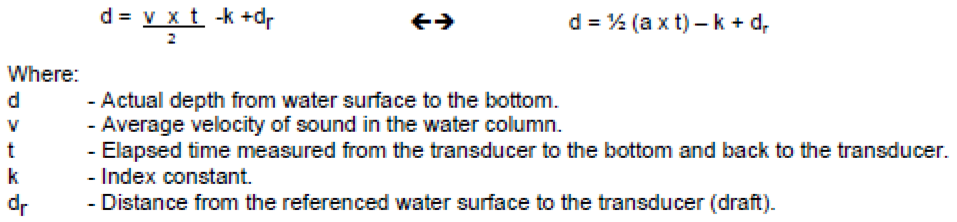
Draft: 0.7

Index: 0.21

Results:

A 50cm offset was observed within the VBES (vertical beam echo sounder) data in comparison with the reference surface from 2904’s 2040 MBES (multibeam echo sounder). This offset was observed, after the Dynamic Draft model of the vessel was updated for field season 2019, within data that was acquired for a 2019 project. The Reference surface data was revisited with the new dynamic draft model and the 50cm offset was apparent. After further investigation the offset was attributed to the Draft and Index value within the ODOM controller. The ODOM manual states that the bar check procedure is used to correct for sound velocity in case you do not have a sound velocity probe. Sound velocity was then corrected for during post processing essentially double correcting for sound velocity.

Within the Caris HVF, the reciprocal value of the draft and index value was used in order to back out the values from the raw data. The value set under SVP1 within the hvf is -0.49. This value was arrived at by using a formula taken from ECHOTRAC CV200 USER MANUAL Version: 4.04 (Figure 1).

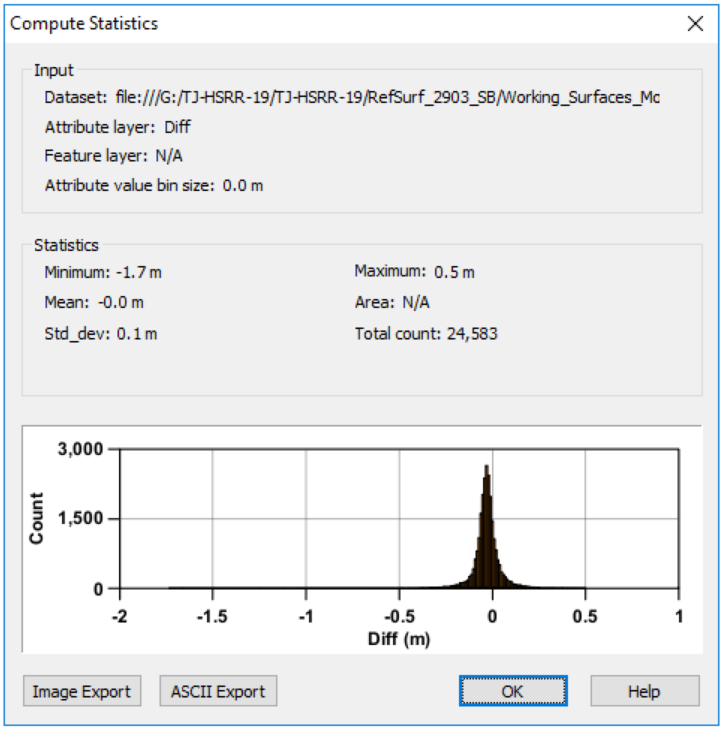


$$d = \frac{v \times t}{2} - k + d_r \quad \leftrightarrow \quad d = \tfrac{1}{2}(a \times t) - k + d_r$$

Where:

d - Actual depth from water surface to the bottom.
v - Average velocity of sound in the water column.
t - Elapsed time measured from the transducer to the bottom and back to the transducer.
k - Index constant.
d_r - Distance from the referenced water surface to the transducer (draft).

Figure 1: Formula from ECHOTRAC CV200 USER MANUAL Version: 4.04



Input

Dataset: file:///G:/TJ-HSRR-19/TJ-HSRR-19/RefSurf_2903_SB/Working_Surfaces_Mc

Attribute layer: Diff

Feature layer: N/A

Attribute value bin size: 0.0 m

Statistics

Minimum: -1.7 m

Maximum: 0.5 m

Mean: -0.0 m

Area: N/A

Std_dev: 0.1 m

Total count: 24,583

Figure 2: Difference surface statistics

Two Cube surfaces were created for VBES and MBES. These surfaces were gridded at four meters For the VBES data and 50-centimeters for the 2040 MBES data. These two surfaces were then differenced. Nine lines of the ten VBES lines collected were used for the difference statistics, as the tenth line is located directly over a wreck. The results were a mean of 0.00 with a standard deviation of 0.1 (Figure 2).

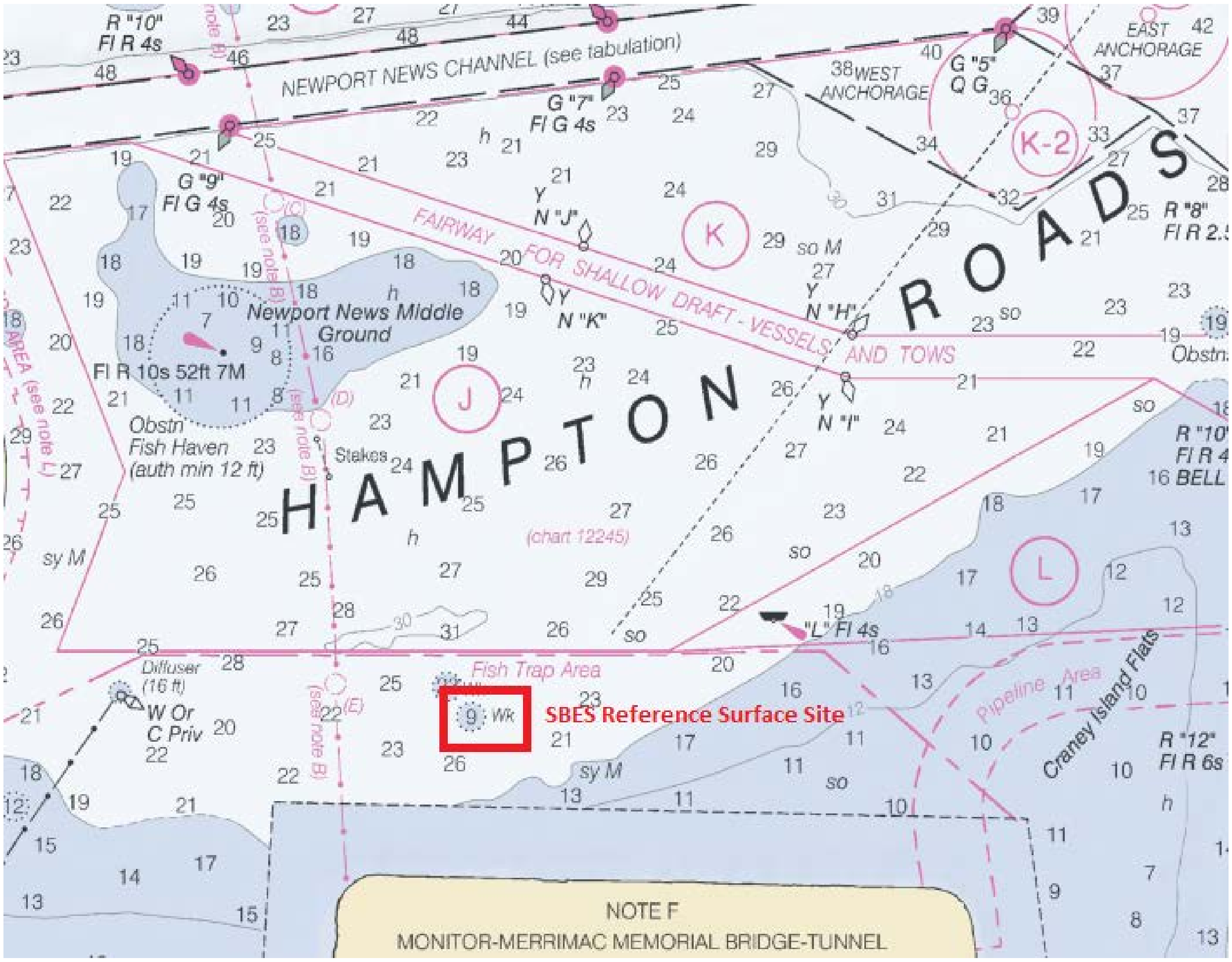


Figure : Location of SBES reference surface.

Kongsberg EM2040 Calibration and Verification on NOAA ship *Thomas Jefferson,* HSL 2904

07/16/2019

Calibration

Waterline measurements were made on both the port and starboard sides of HSL 2904 using benchmarks BM PORT 1 and BM STAR 1. An average of these values was used with the vertical transducer offset and vertical vessel survey values to calculate the static draft value for the transducer which was found to be +0.618m.

A patch test was conducted incorrectly on 5/23/2019. The acquisition of the data collected on 5/23/2019 was collected incorrectly. As a result, a roll offset of 0.302 was observed within four days of data of Project OPR-E350-TJ-19. The correct offset value of 0.302 was applied to the data collected with the incorrect patch test values via SVP2 within the caris HVF for those four days exclusively.

A patch test was conducted correctly on 7/15/2019 and performed according to guidance from FPM 2014. The patch test was performed over a wreck located north of Craney Island Disposal Area in Hampton Roads, VA at 36° 55’51.153, -76° 22’ 45.9012. Thirteen lines were acquired for the patch test, although not all lines were used to identify biases. Line numbers 0002_20190715_113508_2904_EM2040, 0003_20190715_113702_2904_EM2040, 0004_20190715_113859_2904_EM2040, 0005_20190715_114125_2904_EM2040, and 0007_20190715_114751_2904_EM2040 were used to correct for Time, Pitch, Roll, and Yaw biases.

Interference from the mounted Edgetech 4200 Side scan sonar can be seen in the starboard beams 382-400. This data has been rejected from the Caris Hips project (Figure 1). This data has been rejected for the patch test and reference surface data.

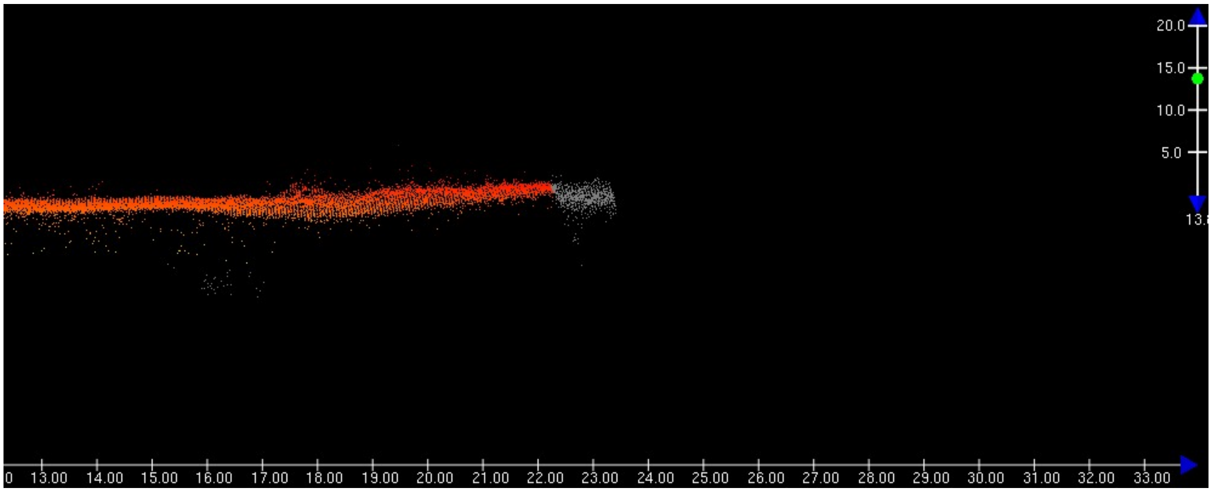


Figure 1: Interference of Side scan sonar.

Results of the patch test can be found further in this DAPR.

Pitch:

003: Heading 180°

004: Heading 359°

Roll:

005: Heading 180°

007: Heading 178°

Yaw:

002: Heading 0°

005: Heading 180°

007: Heading 178°

A CTD cast was performed during acquisition of a reference surface in order to correct for sound speed differences during post processing. The planned line plan shown below (Figure 2). Location of collected lines of data may vary from planned lines.

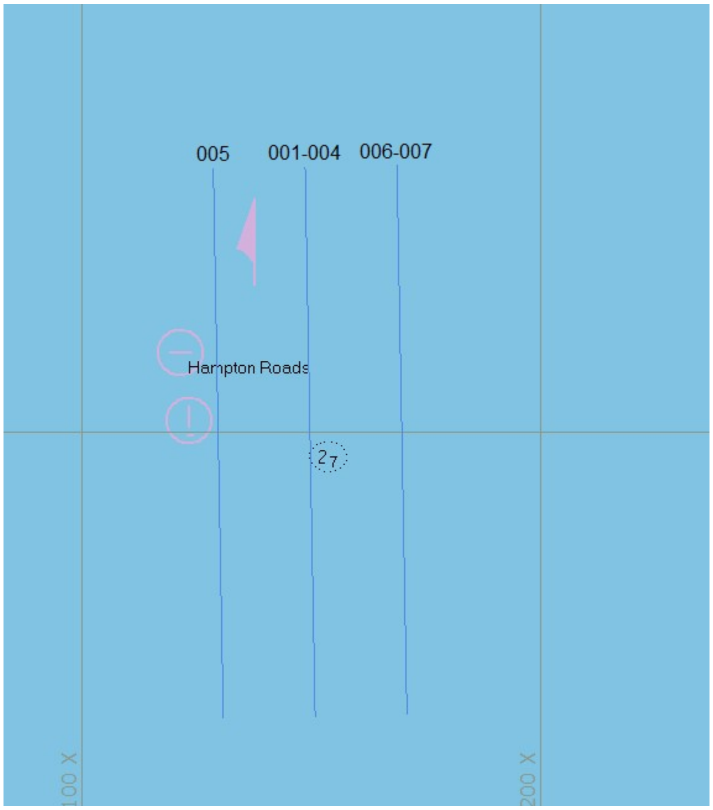


Figure 2: Planned lines over wreck for patch test conducted on 7/15/2019.

Verification

Data for a reference surface were collected on July 15, 2019 over a wreck located north of Craney Island Disposal Area in Hampton Roads, VA at 36° 55’51.153, -76° 22’ 45.9012. A CTD cast was performed prior to data collection in the near vicinity. Ten lines were collected over the wreck. Location of Reference surface can be seen below (Figure 3).

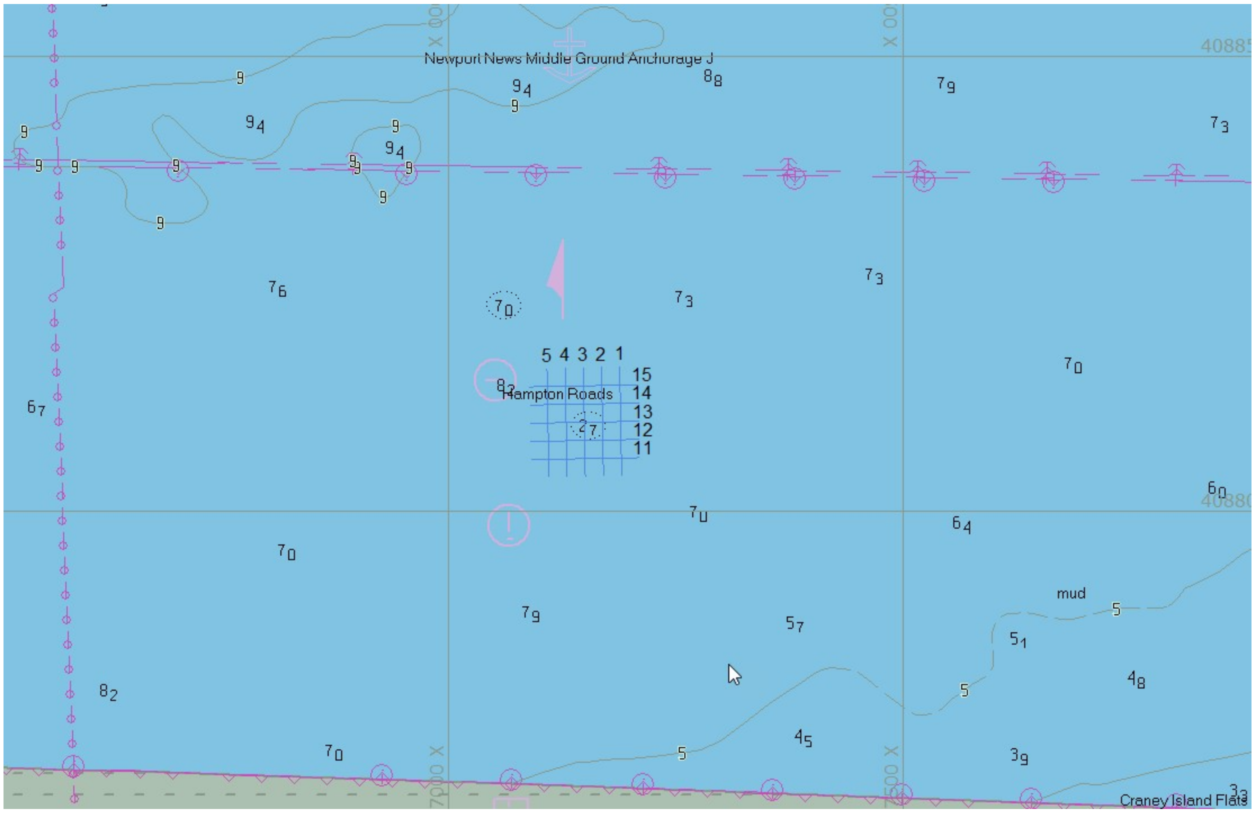
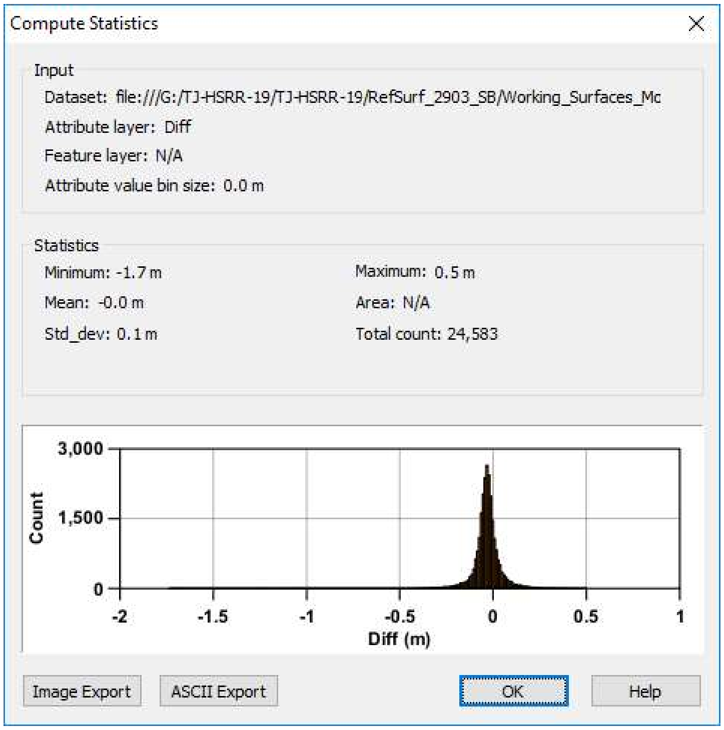


Figure 3: Location of MBES reference surface.

Results:

A patch test was conducted incorrectly on 5/23/2019. The acquisition of the data collected on 5/23/2019 was collected incorrectly. As a result, a roll offset of 0.302 was observed within four days of data of Project OPR-E350-TJ-19. The correct offset value of 0.302 was applied to the data collected with the incorrect patch test values via SVP2 within the caris HVF for those four days exclusively.

A roll offset of 0.27 and 0.11 was observed within the data and applied to the data for DN152-196 for 0.27 and DN196-197 for 0.11 via Caris HVF. This roll offset was added to the previous roll offset value and applied via Applanix POS for data collected going forward for field season 2019.



Compute Statistics

Input

Dataset: file:///G:/TJ-HSRR-19/TJ-HSRR-19/RefSurf_2903_SB/Working_Surfaces_Mc

Attribute layer: Diff

Feature layer: N/A

Attribute value bin size: 0.0 m

Statistics

Minimum: -1.7 m

Maximum: 0.5 m

Mean: -0.0 m

Area: N/A

Std_dev: 0.1 m

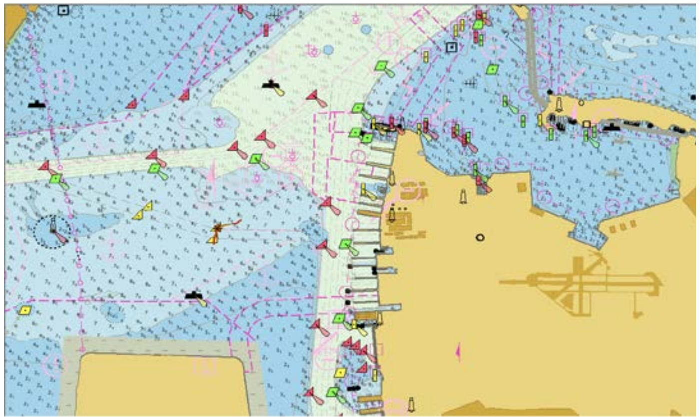
Total count: 24,583

Figure 4: Difference surface statistics

Two Cube surfaces were created for VBES and MBES. These surfaces were gridded at four meters For the VBES data and 50-centimeters for the 2040 MBES data. These two surfaces were then differenced. The results were a mean of 0.00 with a standard deviation of 0.1 (Figure 4).

NOAA Launch 2903 Sidescan Calibration - 25mRS
Side Scan run on Dn183. MBES not acquired.

MBES postion of contact aqcuired with launch 2904 with patch values from field season 2018



MBES Position of Contact

	Lat	Long
	36.945958	-76.360074

SSS Contacts

	Lat	Long	Line Hdg	Lat Diff (m)	Long Diff (m)	Dist. (m)	Along Trk (m)	Across Trk (m)	Dist. (m)
1	36.9459600	-76.3600760	271.470	0.22	-0.18	0.28	-0.18	0.222	0.28
2	36.945956	-76.3600750	342.932	-0.22	-0.09	0.24	-0.15	-0.186	0.24
3	36.945953	-76.3600750	0.309	-0.56	-0.09	0.56	-0.09	-0.556	0.56
4	36.945959	-76.3600760	177.482	0.11	-0.18	0.21	0.17	-0.119	0.21
5	36.945956	-76.3600750	270.661	-0.22	-0.09	0.24	-0.22	0.086	0.24
6	36.945955	-76.3600750	91.022	-0.33	-0.09	0.34	0.33	-0.083	0.34
7	36.945951	-76.3600760	359.568	-0.78	-0.18	0.80	-0.18	-0.776	0.80
8	36.945957	-76.3600760	270.738	-0.11	-0.18	0.21	-0.11	0.176	0.21
9	36.945959	-76.3600770	272.337	0.11	-0.27	0.29	0.10	0.271	0.29
10	36.945953	-76.3600770	357.207	-0.56	-0.27	0.62	-0.29	-0.542	0.62

N	10	Average:	-0.23	-0.16	0.38	-0.20
DOF: 2N-1	19	StDev:	0.33	0.07	0.21	0.23

Criteria: 95% Confidence that any future measurement will not give a positional error greater than 5 meters.

Assuming x and y errors are goverened by the same normal distribution, the square of the distance error is governed by Chi-squared statistics.

So:

$$P\left[d^2 > \frac{\sigma^2\chi^2_{n;\alpha}}{n}\right] = \alpha$$

Setting the distance error equal to 05 meters and using the Chi-squared value for one degree of freedom and alpha = 0.05, solve for the maximum value for the true value of the standard deviation of the x and y error.

Distance Error Limit (meters)	5
Max. x,y Std Deviation	5.1

The sample estimate of the standard deviation will also be Chi-squared distributed

At a 95% confidence interval the standard deviation range is:

	best est.	95% Confidence	
x,y StDev	0.2	0.3	

And the 95% confidence inteval of the positioning error is:

Error	0.5	**0.6**	**PASS**

Note: FPM method of 1.96*RMS standard deviation

Error: 0.7 **PASS**

Alternate FPM method of mean radial distance plus 1.96*radial standard deviation

Error 0.8 **PASS**

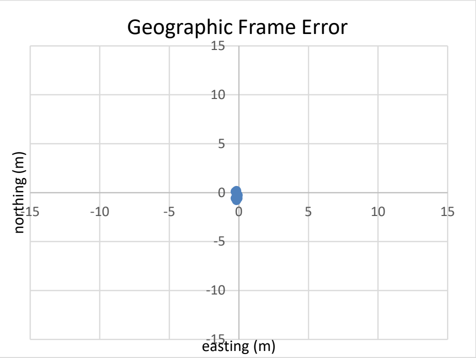


Figure 2: Contact position errors in a geographic refernece frame. Most contacts were reported southwest of the actual position.

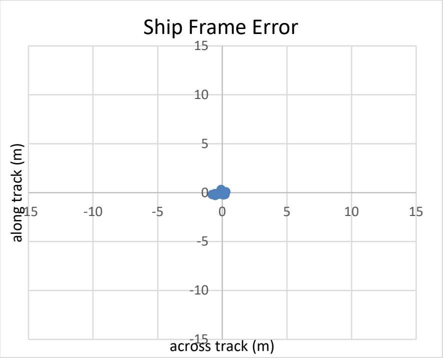
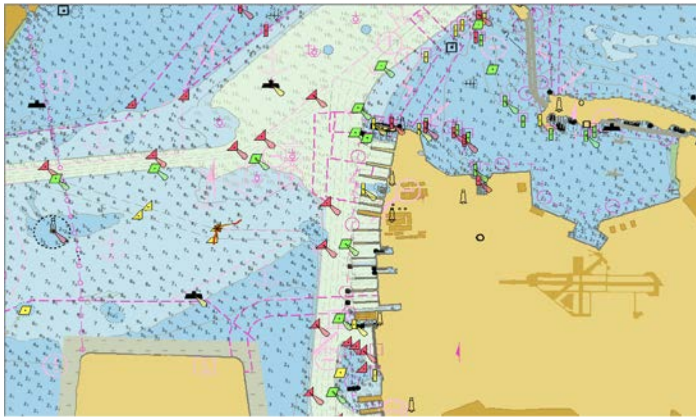


Figure 3: Contact position errors in a ship aligned reference frame.

NOAA Launch 2903 Sidescan Calibration - 50mRS
Side Scan run on Dn155. MBES not acquired.

MBES postion of contact aqcuired with launch 2904 with patch values from field season 2018



MBES Position of Contact

Lat	Long
36.945958	-76.360074

SSS Contacts			Line Hdg	Lat Diff (m)	Long Diff (m)	Dist. (m)	Along Trk (m)	Across Trk (m)	Dist. (m)
1	36.945957	-76.360065	181.103	-0.11	0.80	0.81	0.80	-0.111	0.81
2	36.945955	-76.360064	0.817	-0.33	0.89	0.95	0.89	-0.321	0.95
3	36.945953	-76.360071	89.731	-0.56	0.27	0.62	0.56	0.264	0.62
4	36.945958	-76.360075	270.073	0.00	-0.09	0.09	0.00	0.089	0.09
5	36.945954	-76.360076	269.531	-0.44	-0.18	0.48	-0.44	0.181	0.48
6	36.945958	-76.360079	89.507	0.00	-0.44	0.44	0.00	-0.444	0.44
7	36.945958	-76.360080	0.818	0.00	-0.53	0.53	-0.53	-0.008	0.53
8	36.945954	-76.360080	270.472	-0.44	-0.53	0.69	-0.45	0.529	0.69
9	36.945952	-76.360082	178.782	-0.67	-0.71	0.97	0.72	0.651	0.97
10	36.945956	-76.360090	178.265	-0.22	-1.42	1.44	1.43	0.179	1.44
N	10		Average:	-0.28	-0.20	0.70	-0.24		
DOF: 2N-1	19		StDev:	0.25	0.70	0.37	0.51		

Criteria: 95% Confidence that any future measurement will not give a positional error greater than 10 meters.

Assuming x and y errors are goverened by the same normal distribution, the square of the distance error is governed by Chi-squared statistics.

So:

$$P\left[d^2 > \frac{\sigma^2 \chi^2_{n;\alpha}}{n}\right] = \alpha$$

Setting the distance error equal to 05 meters and using the Chi-squared value for one degree of freedom and alpha = 0.05, solve for the maximum value for the true value of the standard deviation of the x and y error.

Distance Error Limit (meters)	5
Max. x,y Std Deviation	5.1

The sample estimate of the standard deviation will also be Chi-squared distributed

At a 95% confidence interval the standard deviation range is:

	best est.	95% Confidence
x,y StDev	0.5	0.7

And the 95% confidence inteval of the positioning error is:

Error	1.0	**1.4**	**PASS**

Note: FPM method of 1.96*RMS standard deviation

Error: 1.5 **PASS**

Alternate FPM method of mean radial distance plus 1.96*radial standard deviation

Error 1.4 **PASS**

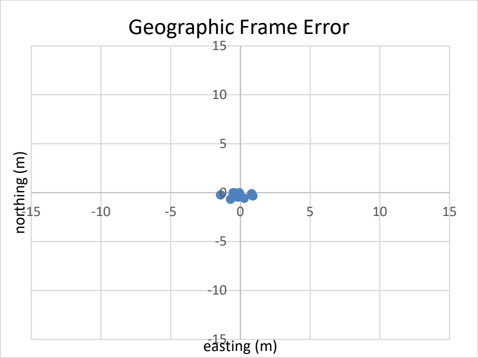


Figure 2: Contact position errors in a geographic refernece frame. Most contacts were reported southwest of the actual position.

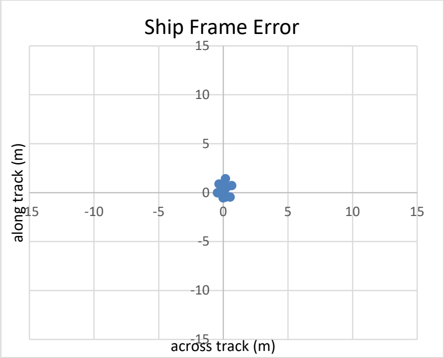
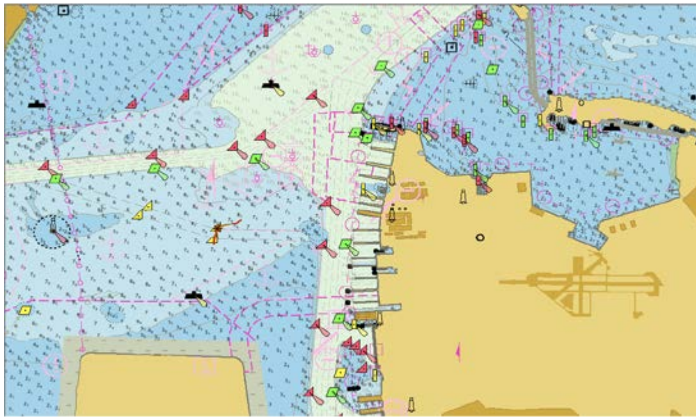


Figure 3: Contact position errors in a ship aligned reference frame.

NOAA Launch 2903 Sidescan Calibration - 75mRS
Side Scan run on Dn155. MBES not acquired.

MBES postion of contact aqcuired with launch 2904 with patch values from field season 2018



MBES Position of Contact

Lat	Long
36.945958	-76.360074

SSS Contacts			Line Hdg	Lat Diff (m)	Long Diff (m)	Dist. (m)	Along Trk (m)	Across Trk (m)	Dist. (m)
1	36.945958	-76.360083	178.375	0.00	-0.80	0.80	-0.80	0.000	0.80
2	36.945953	-76.360076	0.817	-0.56	-0.18	0.58	-0.17	-0.558	0.58
3	36.945958	-76.360071	179.742	0.00	0.27	0.27	-0.27	0.001	0.27
4	36.945948	-76.360078	178.343	-1.11	-0.36	1.17	0.39	1.100	1.17
5	36.945958	-76.360081	359.963	0.00	-0.62	0.62	-0.62	0.000	0.62
6	36.945958	-76.360089	178.967	0.00	-1.33	1.33	1.33	-0.024	1.33
7	36.945957	-76.360088	270.818	-0.11	-1.24	1.25	-0.13	1.242	1.25
8	36.945958	-76.360071	89.567	0.00	0.27	0.27	0.00	0.266	0.27
9	36.945966	-76.360086	270.106	0.89	-1.07	1.39	0.89	1.067	1.39
10	36.945949	-76.360069	87.872	-1.00	0.44	1.09	1.02	0.407	1.09
11	36.945953	-76.360082	271.681	-0.56	-0.71	0.90	-0.58	0.694	0.90
12	36.945948	-76.360087	269.513	-1.11	-1.15	1.60	-1.10	1.164	1.60
N	12		Average:	-0.30	-0.54	0.94	-0.42		
DOF: 2N-1	23		StDev:	0.59	0.63	0.44	0.61		

Criteria: 95% Confidence that any future measurement will not give a positional error greater than 10 meters.

Assuming x and y errors are goverened by the same normal distribution, the square of the distance error is governed by Chi-squared statistics.

So:

$$P\left[d^2 > \frac{\sigma^2 \chi^2_{n;\alpha}}{n}\right] = \alpha$$

Setting the distance error equal to 05 meters and using the Chi-squared value for one degree of freedom and alpha = 0.05, solve for the maximum value for the true value of the standard deviation of the x and y error.

Distance Error Limit (meters)	5
Max. x,y Std Deviation	5.1

The sample estimate of the standard deviation will also be Chi-squared distributed

At a 95% confidence interval the standard deviation range is:

	best est.	95% Confidence	
x,y StDev	0.6	0.8	

And the 95% confidence inteval of the positioning error is:

Error	1.2	**1.6**	**PASS**

Note: FPM method of 1.96*RMS standard deviation

Error: 1.7 **PASS**

Alternate FPM method of mean radial distance plus 1.96*radial standard deviation

Error 1.8 **PASS**

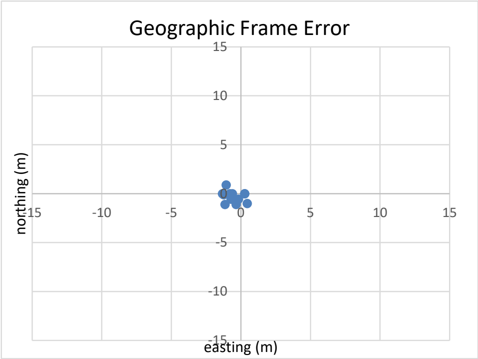

Geographic Frame Error

Figure 2: Contact position errors in a geographic refernece frame. Most contacts were reported southwest of the actual position.

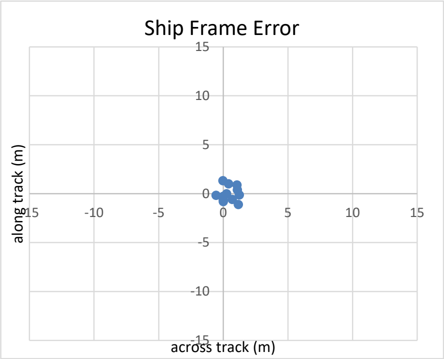
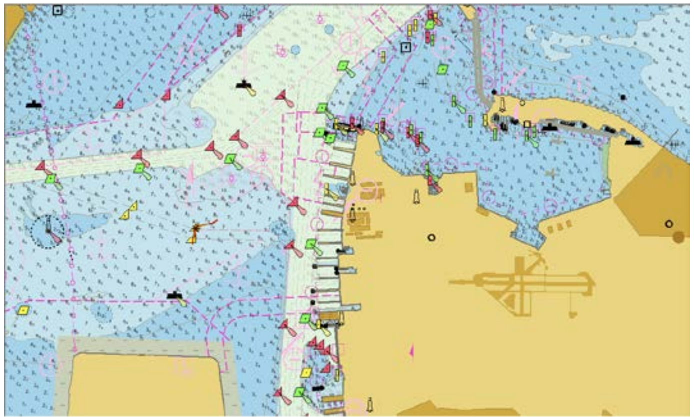

Ship Frame Error

Figure 3: Contact position errors in a ship aligned reference frame.

NOAA Launch 2903 Sidescan Calibration - 100mRS
Side Scan run on Dn183. MBES not acquired.

MBES postion of contact aqcuired with launch 2904 with patch values from field season 2018



MBES Position of Contact

Lat	Long
36.945958	-76.360074

SSS Contacts			Line Hdg	Lat Diff (m)	Long Diff (m)	Dist. (m)	Along Trk (m)	Across Trk (m)	Dist. (m)
1	36.945969	-76.360062	180.106	1.22	1.07	1.62	1.07	1.222	1.62
2	36.945959	-76.360071	0.299	0.11	0.27	0.29	0.27	0.113	0.29
3	36.945949	-76.360087	179.555	-1.00	-1.15	1.53	1.16	0.991	1.53
4	36.94596	-76.360080	0.348	0.22	-0.53	0.58	-0.53	0.219	0.58
5	36.945953	-76.360084	181.020	-0.56	-0.89	1.05	0.88	0.571	1.05
6	36.945958	-76.360070	180.133	0.00	0.36	0.36	-0.36	-0.001	0.36
7	36.945946	-76.360078	269.753	-1.33	-0.36	1.38	-1.33	0.361	1.38
8	36.945959	-76.360076	89.327	0.11	-0.18	0.21	-0.11	-0.176	0.21
9	36.945971	-76.360070	270.152	1.44	0.36	1.49	1.45	-0.351	1.49
10	36.945954	-76.360072	89.712	-0.44	0.18	0.48	0.45	0.175	0.48
11	36.945965	-76.360076	269.981	0.78	-0.18	0.80	0.78	0.177	0.80
12	36.945952	-76.360071	269.085	-0.67	0.27	0.72	-0.67	-0.256	0.72
N	12		Average:	-0.01	-0.07	0.87	-0.04		
DOF: 2N-1	23		StDev:	0.85	0.61	0.52	0.73		

Criteria: 95% Confidence that any future measurement will not give a positional error greater than 10 meters.

Assuming x and y errors are goverened by the same normal distribution, the square of the distance error is governed by Chi-squared statistics.

So:

$$P\left[d^2 > \frac{\sigma^2 \chi^2_{n;\alpha}}{n}\right] = \alpha$$

Setting the distance error equal to 05 meters and using the Chi-squared value for one degree of freedom and alpha = 0.05, solve for the maximum value for the true value of the standard deviation of the x and y error.

Distance Error Limit (meters)	5
Max. x,y Std Deviation	5.1

The sample estimate of the standard deviation will also be Chi-squared distributed

At a 95% confidence interval the standard deviation range is:

	best est.	95% Confidence
x,y StDev	0.7	1.0

And the 95% confidence inteval of the positioning error is:

Error	1.4	**1.9**	**PASS**

Note: FPM method of 1.96*RMS standard deviation

Error: 2.1 **PASS**

Alternate FPM method of mean radial distance plus 1.96*radial standard deviation

Error 1.9 **PASS**

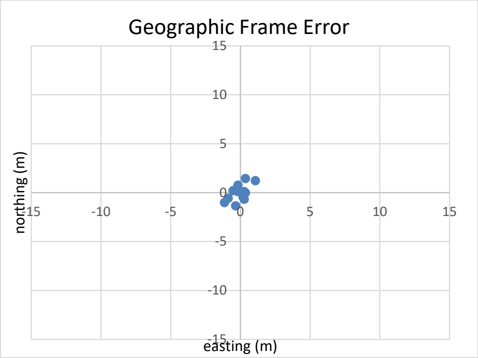


Figure 2: Contact position errors in a geographic refernece frame. Most contacts were reported southwest of the actual position.

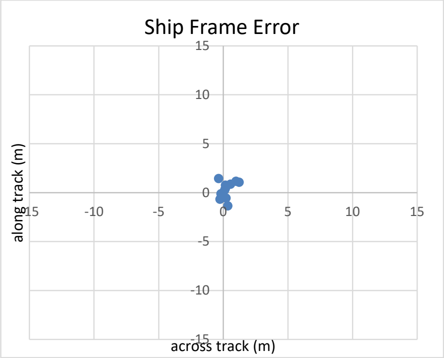


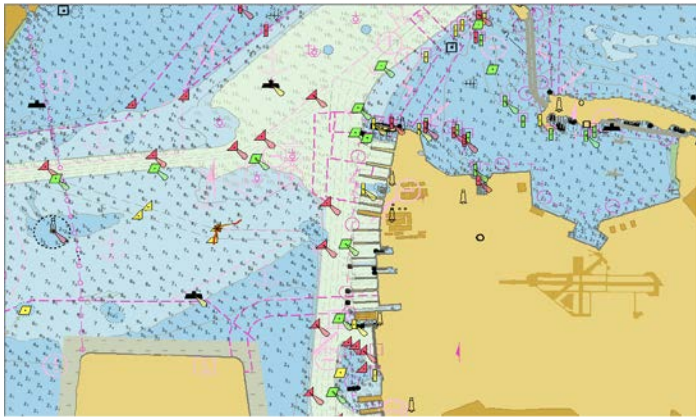
Figure 3: Contact position errors in a ship aligned reference frame.

NOAA Launch 2903 Sidescan Calibration (klein) - 50mRS
Side Scan run on Dn205. MBES not acquired.

MBES postion of contact aqcuired with launch 2904 with patch values from field season 2018

MBES Position of Contact

	Lat	Long
	36.945958	-76.360074



SSS Contacts			Line Hdg	Lat Diff (m)	Long Diff (m)	Dist. (m)	Along Trk (m)	Across Trk (m)	Dist. (m)
1	36.945957	-76.360053	0.625	-0.11	1.86	1.87	1.86	-0.111	1.87
2	36.945954	-76.360054	359.948	-0.44	1.78	1.83	1.78	-0.446	1.83
3	36.945965	-76.360058	196.130	0.78	1.42	1.62	-1.15	-1.142	1.62
4	36.945977	-76.360064	271.544	2.11	0.89	2.29	2.13	-0.831	2.29
5	36.945968	-76.360064	270.432	1.11	0.89	1.42	1.12	-0.880	1.42
6	36.945942	-76.360073	271.262	-1.78	0.09	1.78	-1.78	-0.128	1.78
7	36.94597	-76.360082	89.720	1.33	-0.71	1.51	-1.34	-0.704	1.51
8	36.945956	-76.360090	0.777	-0.22	-1.42	1.44	-1.42	-0.241	1.44
9	36.945954	-76.360092	178.968	-0.44	-1.60	1.66	1.61	0.416	1.66
10	36.945945	-76.360094	0.584	-1.44	-1.78	2.29	-1.76	-1.463	2.29
11	36.945953	-76.3600870	91.475	-0.56	-1.15	1.28	0.59	-1.140	1.28
N	11		Average:	0.03	0.02	1.73	0.03		
DOF: 2N-1	21		StDev:	1.19	1.41	0.33	1.27		

Criteria: 95% Confidence that any future measurement will not give a positional error greater than 10 meters.

Assuming x and y errors are goverened by the same normal distribution, the square of the distance error is governed by Chi-squared statistics.

So:

$$P\left[d^2 > \frac{\sigma^2\chi^2_{n;\alpha}}{n}\right] = \alpha$$

Setting the distance error equal to 05 meters and using the Chi-squared value for one degree of freedom and alpha = 0.05, solve for the maximum value for the true value of the standard deviation of the x and y error.

Distance Error Limit (meters)	5
Max. x,y Std Deviation	5.1

The sample estimate of the standard deviation will also be Chi-squared distributed

At a 95% confidence interval the standard deviation range is:

	best est.	95% Confidence	
x,y StDev	1.3	1.7	

And the 95% confidence inteval of the positioning error is:

Error	2.5	**3.4**	**PASS**

Note: FPM method of 1.96*RMS standard deviation

Error: 3.6 **PASS**

Alternate FPM method of mean radial distance plus 1.96*radial standard deviation

Error 2.4 **PASS**

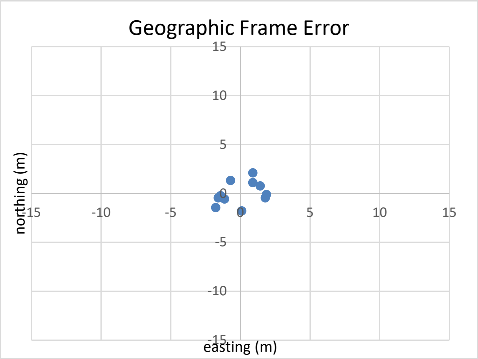


Figure 2: Contact position errors in a geographic refernece frame. Most contacts were reported southwest of the actual position.

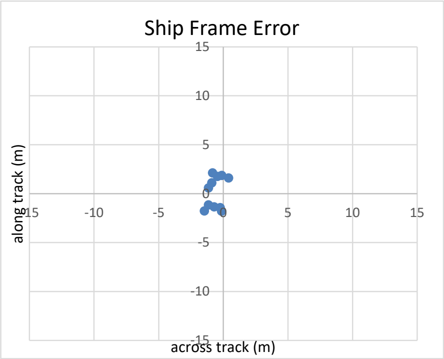
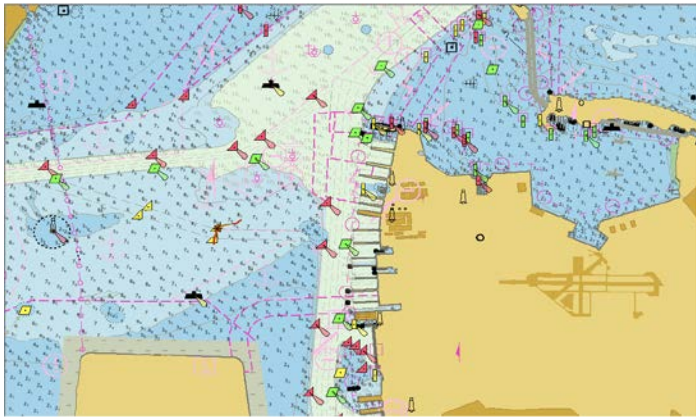


Figure 3: Contact position errors in a ship aligned reference frame.

NOAA Launch 2903 Sidescan Calibration (klein) - 75mRS
Side Scan run on Dn205. MBES not acquired.

MBES postion of contact aqcuired with launch 2904 with patch values from field season 2018



MBES Position of Contact

	Lat	Long
	36.945958	-76.360074

SSS Contacts			Line Hdg	Lat Diff (m)	Long Diff (m)	Dist. (m)	Along Trk (m)	Across Trk (m)	Dist. (m)
1	36.945957	-76.360061	359.585	-0.11	1.15	1.16	1.15	-0.111	1.16
2	36.945949	-76.360057	359.824	-1.00	1.51	1.81	1.51	-1.005	1.81
3	36.945946	-76.360072	270.993	-1.33	0.18	1.35	-1.33	-0.201	1.35
4	36.945947	-76.360075	90.324	-1.22	-0.09	1.23	1.22	-0.082	1.23
5	36.94596	-76.360079	179.373	0.22	-0.44	0.50	0.44	-0.227	0.50
6	36.945964	-76.360091	90.644	0.67	-1.51	1.65	-0.65	-1.517	1.65
7	36.945959	-76.360092	179.375	0.11	-1.60	1.60	1.60	-0.129	1.60
8	36.945951	-76.360091	359.810	-0.78	-1.51	1.70	-1.51	-0.773	1.70
9	36.945944	-76.360095	358.884	-1.56	-1.86	2.43	-1.89	-1.519	2.43
10	36.94596	-76.360079	179.373	0.22	-0.44	0.50	0.44	-0.227	0.50
N	10		Average:	-0.48	-0.46	1.39	-0.47		
DOF: 2N-1	19		StDev:	0.79	1.18	0.59	0.98		

Criteria: 95% Confidence that any future measurement will not give a positional error greater than 10 meters.

Assuming x and y errors are goverened by the same normal distribution, the square of the distance error is governed by Chi-squared statistics.

So:

$$P\left[d^2 > \frac{\sigma^2 \chi^2_{n;\alpha}}{n}\right] = \alpha$$

Setting the distance error equal to 05 meters and using the Chi-squared value for one degree of freedom and alpha = 0.05, solve for the maximum value for the true value of the standard deviation of the x and y error.

Distance Error Limit (meters)	5
Max. x,y Std Deviation	5.1

The sample estimate of the standard deviation will also be Chi-squared distributed

At a 95% confidence interval the standard deviation range is:

	best est.	95% Confidence
x,y StDev	1.0	1.3

And the 95% confidence inteval of the positioning error is:

Error	1.9	**2.6**	**PASS**

Note: FPM method of 1.96*RMS standard deviation

Error: 2.8 **PASS**

Alternate FPM method of mean radial distance plus 1.96*radial standard deviation

Error 2.6 **PASS**

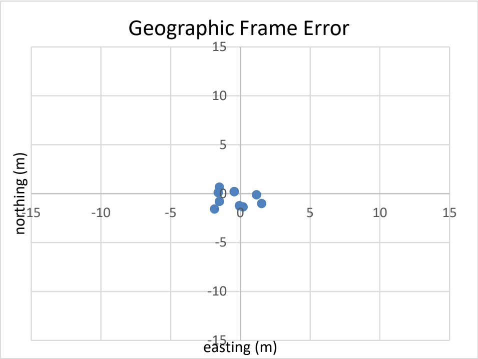


Figure 2: Contact position errors in a geographic refernece frame. Most contacts were reported southwest of the actual position.

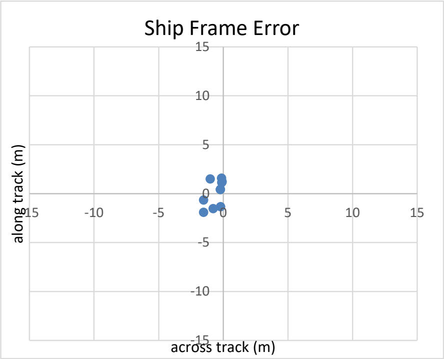
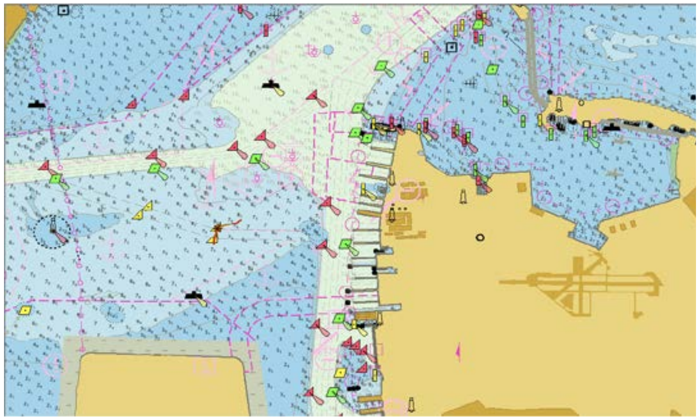


Figure 3: Contact position errors in a ship aligned reference frame.

NOAA Launch 2903 Sidescan Calibration (klein) - 100mRS
Side Scan run on Dn205. MBES not acquired.

MBES postion of contact aqcuired with launch 2904 with patch values from field season 2018



MBES Position of Contact

	Lat	Long
	36.945958	-76.360074

SSS Contacts			Line Hdg	Lat Diff (m)	Long Diff (m)	Dist. (m)	Along Trk (m)	Across Trk (m)	Dist. (m)
1	36.945952	-76.360056	271.050	-0.67	1.60	1.73	1.60	-0.667	1.73
2	36.945953	-76.360061	0.021	-0.56	1.15	1.28	1.15	-0.555	1.28
3	36.94597	-76.360068	179.032	1.33	0.53	1.44	-0.56	-1.324	1.44
4	36.945969	-76.360067	271.589	1.22	0.62	1.37	1.24	-0.588	1.37
5	36.945954	-76.360075	90.379	-0.44	-0.09	0.45	0.45	-0.086	0.45
6	36.945969	-76.360083	89.557	1.22	-0.80	1.46	-1.23	-0.790	1.46
7	36.945953	-76.360084	359.661	-0.56	-0.89	1.05	-0.89	-0.550	1.05
8	36.945971	-76.360095	179.414	1.44	-1.86	2.36	1.85	-1.464	2.36
9	36.945951	-76.360096	0.224	-0.78	-1.95	2.10	-1.95	-0.785	2.10
10	36.945971	-76.360103	91.187	1.44	-2.58	2.95	-1.39	-2.605	2.95

N	10	Average:	0.37	-0.43	1.62	-0.03
DOF: 2N-1	19	StDev:	1.03	1.42	0.71	1.27

Criteria: 95% Confidence that any future measurement will not give a positional error greater than 10 meters.

Assuming x and y errors are goverened by the same normal distribution, the square of the distance error is governed by Chi-squared statistics.

So:

$$P\left[d^2 > \frac{\sigma^2\chi^2_{n;\alpha}}{n}\right] = \alpha$$

Setting the distance error equal to 05 meters and using the Chi-squared value for one degree of freedom and alpha = 0.05, solve for the maximum value for the true value of the standard deviation of the x and y error.

Distance Error Limit (meters)	5
Max. x,y Std Deviation	5.1

The sample estimate of the standard deviation will also be Chi-squared distributed

At a 95% confidence interval the standard deviation range is:

	best est.	95% Confidence	
x,y StDev	1.3	1.7	

And the 95% confidence inteval of the positioning error is:

Error	2.5	**3.4**	**PASS**

Note: FPM method of 1.96*RMS standard deviation

Error: 3.4 **PASS**

Alternate FPM method of mean radial distance plus 1.96*radial standard deviation

Error 3.0 **PASS**

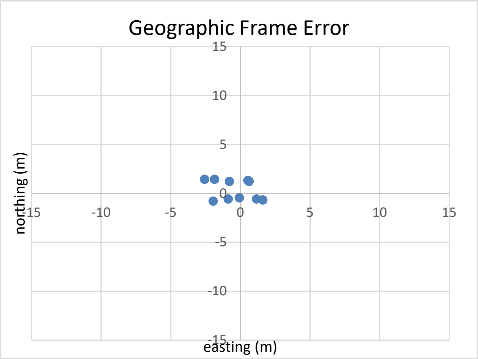


Figure 2: Contact position errors in a geographic refernece frame.

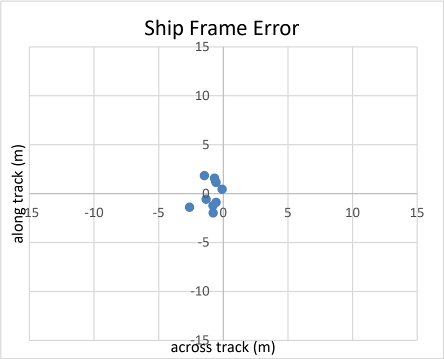
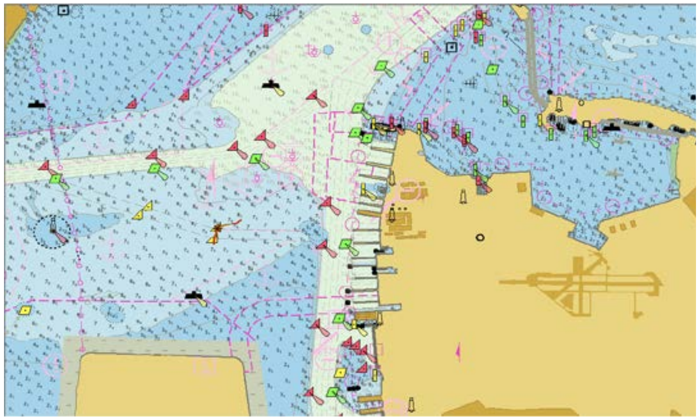


Figure 3: Contact position errors in a ship aligned reference frame.

0

NOAA Launch 2904 Sidescan Calibration - 25mRS
Side Scan run on Dn184. MBES not acquired.

MBES postion of contact aqcuired with launch 2904 with patch values from field season 2018



MBES Position of Contact

Lat	Long
36.945958	-76.360074

SSS Contacts			Line Hdg	Lat Diff (m)	Long Diff (m)	Dist. (m)	Along Trk (m)	Across Trk (m)	Dist. (m)
1	36.9459590	-76.3600610	359.649	0.11	1.15	1.16	1.15	0.111	1.16
2	36.945956	-76.3600640	142.008	-0.22	0.89	0.92	-0.56	0.722	0.92
3	36.945967	-76.3600710	270.131	1.00	0.27	1.03	1.00	-0.264	1.03
4	36.94595	-76.3600730	92.660	-0.89	0.09	0.89	0.88	0.130	0.89
5	36.945972	-76.3600750	271.308	1.56	-0.09	1.56	1.55	0.124	1.56
6	36.94595	-76.3600730	271.281	-0.89	0.09	0.89	-0.89	-0.109	0.89
7	36.945949	-76.3600820	270.243	-1.00	-0.71	1.23	-1.00	0.706	1.23
8	36.945959	-76.3600860	359.392	0.11	-1.07	1.07	-1.06	0.122	1.07
9	36.945959	-76.3600930	359.734	0.11	-1.69	1.69	-1.69	0.119	1.69
10	36.945958	-76.3600810	180.481	0.00	-0.62	0.62	0.62	0.005	0.62
N	10		Average:	-0.01	-0.17	1.11	-0.09		
DOF: 2N-1	19		StDev:	0.82	0.87	0.32	0.83		

Criteria: 95% Confidence that any future measurement will not give a positional error greater than 10 meters.

Assuming x and y errors are goverened by the same normal distribution, the square of the distance error is governed by Chi-squared statistics.

So:

$$\boxed{P\left[d^2 > \frac{\sigma^2 \chi^2_{n;\alpha}}{n}\right] = \alpha}$$

Setting the distance error equal to 05 meters and using the Chi-squared value for one degree of freedom and alpha = 0.05, solve for the maximum value for the true value of the standard deviation of the x and y error.

Distance Error Limit (meters)	5
Max. x,y Std Deviation	5.1

The sample estimate of the standard deviation will also be Chi-squared distributed

At a 95% confidence interval the standard deviation range is:

	best est.	95% Confidence
x,y StDev	0.8	1.1

And the 95% confidence inteval of the positioning error is:

Error	1.6	**2.2**	**PASS**

Note: FPM method of 1.96*RMS standard deviation

Error: 2.3 **PASS**

Alternate FPM method of mean radial distance plus 1.96*radial standard deviation

Error 1.7 **PASS**

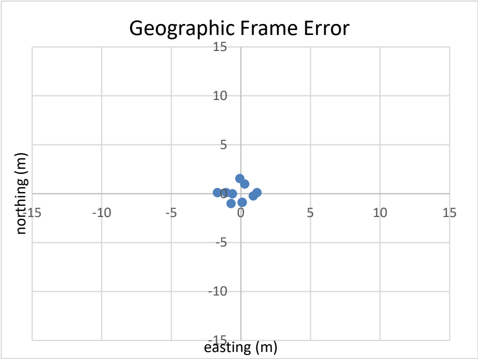


Figure 2: Contact position errors in a geographic refernece frame. Most contacts were reported southwest of the actual position.

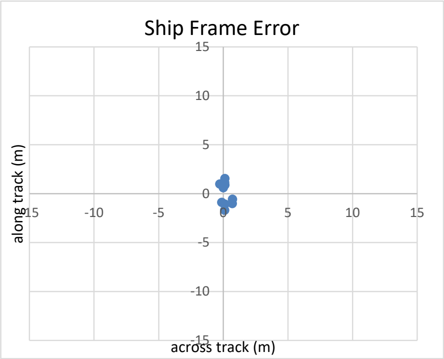
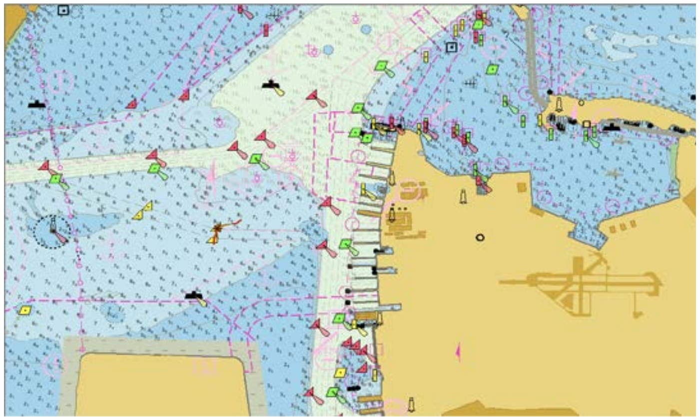


Figure 3: Contact position errors in a ship aligned reference frame.

NOAA Launch 2904 Sidescan Calibration - 50mRS
Side Scan run on Dn184. No MBES aqcuired



MBES Position of Contact

	Lat	Long	Line Hdg	Lat Diff (m)	Long Diff (m)	Dist. (m)	Along Trk (m)	Across Trk (m)	Dist. (m)
	36.945958	-76.360074							
SSS Contacts									
1	36.9459590	-76.3600560	0.397	0.11	1.60	1.60	1.60	0.111	1.60
2	36.94596	-76.3600670	179.738	0.22	0.62	0.66	-0.62	-0.219	0.66
3	36.945951	-76.3600660	91.543	-0.78	0.71	1.05	0.76	0.731	1.05
4	36.94596	-76.3600690	0.183	0.22	0.44	0.50	0.44	0.224	0.50
5	36.945957	-76.3600710	91.489	-0.11	0.27	0.29	0.10	0.269	0.29
6	36.945952	-76.3600780	272.712	-0.67	-0.36	0.76	-0.68	0.323	0.76
7	36.945949	-76.3600770	270.697	-1.00	-0.27	1.03	-1.00	0.254	1.03
8	36.945972	-76.3600810	271.399	1.56	-0.62	1.68	1.54	0.659	1.68
9	36.945969	-76.3600810	271.639	1.22	-0.62	1.37	1.20	0.656	1.37
10	36.945963	-76.3600820	160.289	0.56	-0.71	0.90	0.48	-0.763	0.90
11	36.945964	-76.3600880	359.762	0.67	-1.24	1.41	-1.24	0.672	1.41
12	36.945958	-76.3600930	359.986	0.00	-1.69	1.69	-1.69	0.000	1.69
N	12		Average:	0.17	-0.16	1.08	0.01		
DOF: 2N-1	23		StDev:	0.77	0.92	0.47	0.84		

Criteria: 95% Confidence that any future measurement will not give a positional error greater than 10 meters.

Assuming x and y errors are goverened by the same normal distribution, the square of the distance error is governed by Chi-squared statistics.

So:

$$\boxed{P\left[d^2 > \frac{\sigma^2\chi^2_{n;\alpha}}{n}\right] = \alpha}$$

Setting the distance error equal to 05 meters and using the Chi-squared value for one degree of freedom and alpha = 0.05, solve for the maximum value for the true value of the standard deviation of the x and y error.

Distance Error Limit (meters)	5
Max. x,y Std Deviation	5.1

The sample estimate of the standard deviation will also be Chi-squared distributed

At a 95% confidence interval the standard deviation range is:

	best est.	95% Confidence	
x,y StDev	0.8	1.1	
And the 95% confidence inteval of the positioning error is:			
Error	1.7	**2.2**	**PASS**

Note: FPM method of 1.96*RMS standard deviation

Error: 2.3 **PASS**

Alternate FPM method of mean radial distance plus 1.96*radial standard deviation

Error 2.0 **PASS**

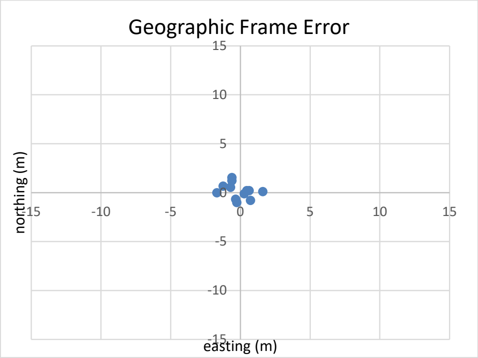


Figure 2: Contact position errors in a geographic refernece frame.

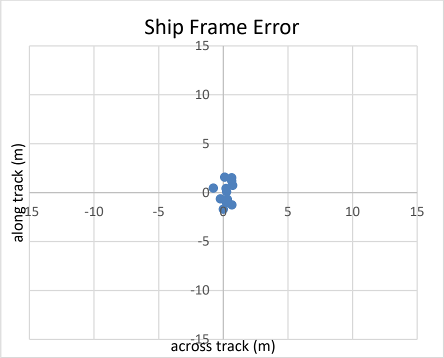
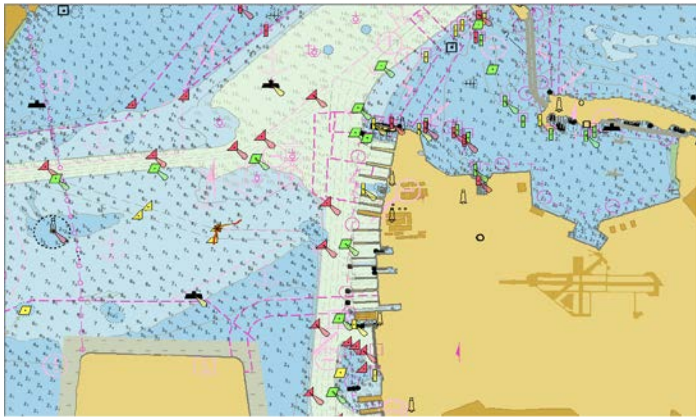


Figure 3: Contact position errors in a ship aligned reference frame.

NOAA Launch 2904 Sidescan Calibration - 75mRS
Side Scan run on Dn184. MBES not acquired.

MBES Position of Contact

Lat	Long
36.945958	-76.360074



SSS Contacts			Line Hdg	Lat Diff (m)	Long Diff (m)	Dist. (m)	Along Trk (m)	Across Trk (m)	Dist. (m)
1	36.9459590	-76.3600490	0.450	0.11	2.22	2.22	2.22	0.111	2.22
2	36.945956	-76.3600640	0.817	-0.22	0.89	0.92	0.89	-0.210	0.92
3	36.945959	-76.3600670	90.926	0.11	0.62	0.63	-0.12	0.620	0.63
4	36.945944	-76.3600690	89.683	-1.56	0.44	1.62	1.56	0.435	1.62
5	36.945982	-76.3600770	271.206	2.67	-0.27	2.68	2.66	0.322	2.68
6	36.945956	-76.3600720	181.337	-0.22	0.18	0.28	-0.18	0.218	0.28
7	36.945941	-76.3600730	271.682	-1.89	0.09	1.89	-1.89	-0.144	1.89
8	36.945969	-76.3600840	270.818	1.22	-0.89	1.51	1.21	0.905	1.51
9	36.945963	-76.3600870	0.289	0.56	-1.15	1.28	-1.16	0.550	1.28
10	36.945955	-76.3600850	180.636	-0.33	-0.98	1.03	0.97	0.344	1.03
11	36.94596	-76.3600940	171.090	0.22	-1.78	1.79	1.72	-0.495	1.79
12	36.945951	-76.3600910	270.023	-0.78	-1.51	1.70	-0.78	1.509	1.70
N	12		Average:	-0.01	-0.18	1.46	-0.09		
DOF: 2N-1	23		StDev:	1.20	1.15	0.68	1.15		

Criteria: 95% Confidence that any future measurement will not give a positional error greater than 10 meters.

Assuming x and y errors are goverened by the same normal distribution, the square of the distance error is governed by Chi-squared statistics.

So:

$$\boxed{P\left[d^2 > \frac{\sigma^2\chi^2_{n;\alpha}}{n}\right] = \alpha}$$

Setting the distance error equal to 05 meters and using the Chi-squared value for one degree of freedom and alpha = 0.05, solve for the maximum value for the true value of the standard deviation of the x and y error.

Distance Error Limit (meters)	5
Max. x,y Std Deviation	5.1

The sample estimate of the standard deviation will also be Chi-squared distributed

At a 95% confidence interval the standard deviation range is:

	best est.	95% Confidence	
x,y StDev	1.2	1.5	

And the 95% confidence inteval of the positioning error is:

Error	2.3	**3.0**	**PASS**

Note: FPM method of 1.96*RMS standard deviation

Error: 3.3 **PASS**

Alternate FPM method of mean radial distance plus 1.96*radial standard deviation

Error 2.8 **PASS**

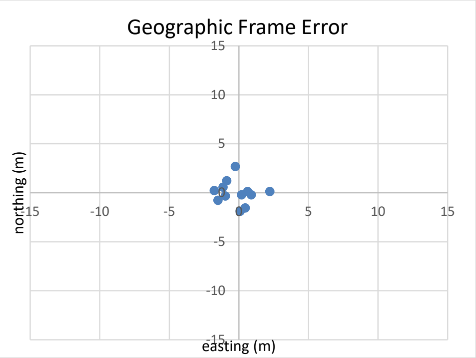


Figure 2: Contact position errors in a geographic refernece frame.

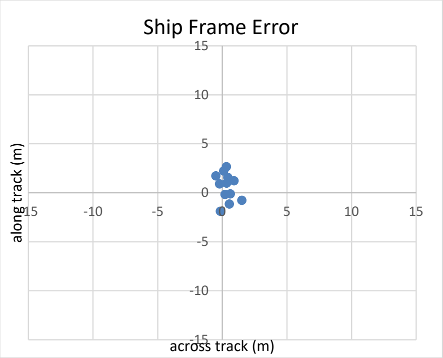
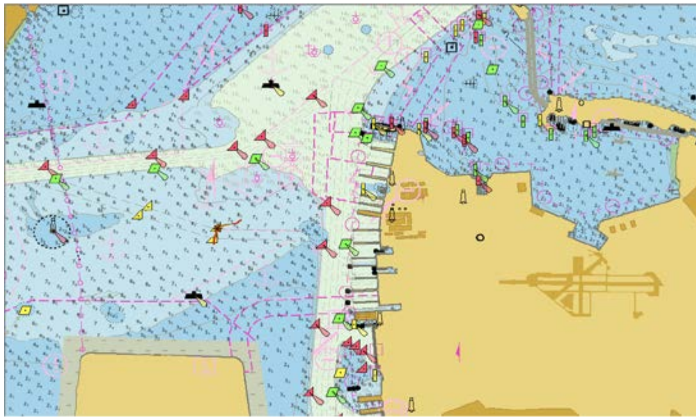


Figure 3: Contact position errors in a ship aligned reference frame.

NOAA Launch 2904 Sidescan Calibration - 100mRS
Side Scan run on Dn184. MBES not acquired.

MBES Position of Contact

Lat	Long
36.945958	-76.360074



SSS Contacts	Lat	Long	Line Hdg	Lat Diff (m)	Long Diff (m)	Dist. (m)	Along Trk (m)	Across Trk (m)	Dist. (m)
1	36.9459550	-76.3600590	0.159	-0.33	1.33	1.37	1.33	-0.333	1.37
2	36.94596	-76.3600630	358.987	0.22	0.98	1.00	0.98	0.205	1.00
3	36.945964	-76.3600730	90.177	0.67	0.09	0.67	-0.67	0.087	0.67
4	36.94597	-76.3600770	270.119	1.33	-0.27	1.36	1.33	0.269	1.36
5	36.945953	-76.3600800	179.512	-0.56	-0.53	0.77	0.54	0.551	0.77
6	36.945951	-76.3600800	90.370	-0.78	-0.53	0.94	0.78	-0.528	0.94
7	36.945947	-76.3600830	269.622	-1.22	-0.80	1.46	-1.22	0.807	1.46
8	36.945941	-76.3600820	269.920	-1.89	-0.71	2.02	-1.89	0.713	2.02
9	36.945967	-76.3600840	270.154	1.00	-0.89	1.34	1.00	0.891	1.34
10	36.945961	-76.3600870	359.481	0.33	-1.15	1.20	-1.15	0.344	1.20
11	36.945954	-76.3600890	359.571	-0.44	-1.33	1.40	-1.34	-0.434	1.40
12	36.945948	-76.3600930	180.081	-1.11	-1.69	2.02	1.69	1.114	2.02
N	12		Average:	-0.23	-0.46	1.30	-0.35		
DOF: 2N-1	23		StDev:	0.97	0.89	0.42	0.92		

Criteria: 95% Confidence that any future measurement will not give a positional error greater than 10 meters.

Assuming x and y errors are goverened by the same normal distribution, the square of the distance error is governed by Chi-squared statistics.

So:

$$\boxed{P\left[d^2 > \frac{\sigma^2 \chi^2_{n;\alpha}}{n}\right] = \alpha}$$

Setting the distance error equal to 05 meters and using the Chi-squared value for one degree of freedom and alpha = 0.05, solve for the maximum value for the true value of the standard deviation of the x and y error.

Distance Error Limit (meters)	5
Max. x,y Std Deviation	5.1

The sample estimate of the standard deviation will also be Chi-squared distributed

At a 95% confidence interval the standard deviation range is:

	best est.	95% Confidence	
x,y StDev	0.9	1.2	

And the 95% confidence inteval of the positioning error is:

Error	1.8	**2.4**	**PASS**

Note: FPM method of 1.96*RMS standard deviation

Error: 2.6 **PASS**

Alternate FPM method of mean radial distance plus 1.96*radial standard deviation

Error 2.1 **PASS**

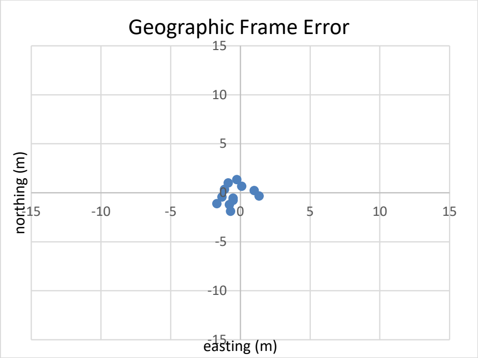


Figure 2: Contact position errors in a geographic refernece frame.

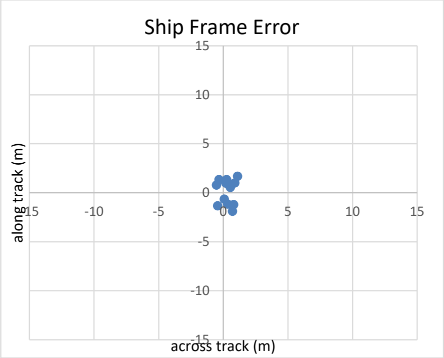


Figure 3: Contact position errors in a ship aligned reference frame.

Echosounder Acceptance Trial Results

KONGSBERG

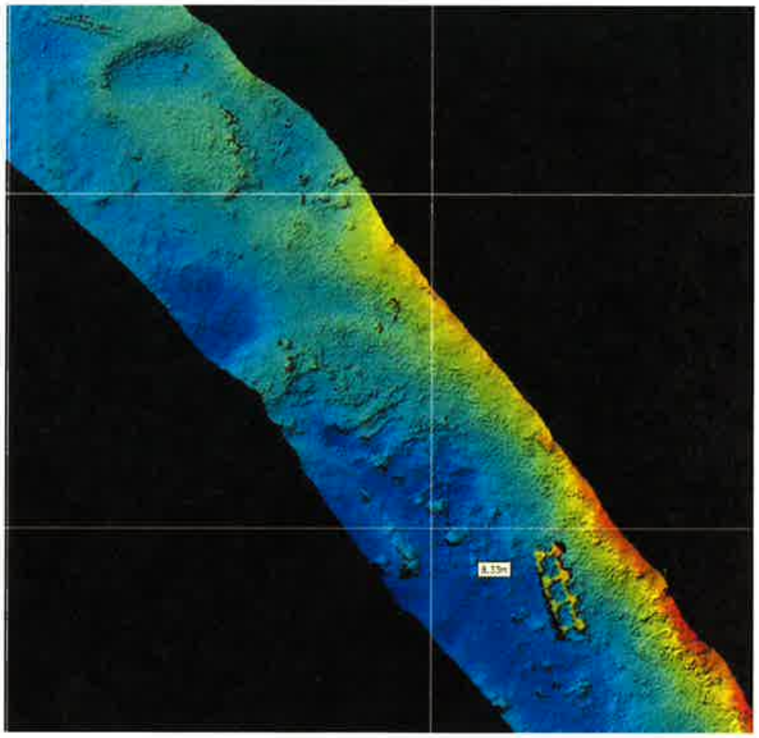
Harbour Acceptance Test

T.J. LAUNCH

*2903

EM 2040

Multibeam Echo Sounder



Document history

Document number	353053	
Rev A	*December 2010*	

Contents

1 INTRODUCTION

The purpose of this procedure is to verify that the system installed is fully functional, and to serve as a record of the successful completion of the Harbour Acceptance Test.

2 REFERENCES

The FAT record.

3 TEST EQUIPMENT

The following test equipment is or may be required to perform this test:

Item	*Equipment*	*Serial number*	*Calibration expiry date*
1			
2			

4 LIST OF ITEMS

These are the items to be tested.

Item	*Registration Number*	*Equipment*	*Serial number*
1	419322	HWS Operator Station	CZC746864F / 1212
2	385412	EM 2040 Processing Unit	40143 — — —
3	338211	TX transducer unit	281
4	338214	RX transducer unit	392 —
5			
6			
7			
8			

5 CONFIGURATION

Fill in the serial numbers of the modules as used in the system during this test.

Configuration list

Product:
EM 2040 Processing Unit

Registration number: 40143

Serial number: 385412

Item	*Equipment*	*Registration number*	*Serial number*
1	PCB CPU Processor Unit	340372	M310665/028
2	PCB BSP 67B-1 Signal processor	~~342174~~ 381169	740852-1804 -CBMF
3	PCB BSP 67B-2 Signal processor	~~342174~~ 381169	740840-1804 -CBMF
4	PCB BSP 67B-3 Signal processor	342174	N/A
5	PCB BSP 67B-4 Signal processor	342174	N/A
6	PCB IO 2040	324145	N/A
7	Ethernet switch – 8 port	343253	N/A
	Ethernet switch – 5 port	307828	N/A

Configuration list

Product:
EM 2040 Processing Unit

Registration number:

Serial number:

Item	*Equipment*	*Registration number*	*Serial number*
1	PCB CPU Processor Unit	340372	
2	PCB BSP 67B-1 Signal processor	342174	
3	PCB BSP 67B-2 Signal processor	342174	
4	PCB BSP 67B-3 Signal processor	342174	
5	PCB BSP 67B-4 Signal processor	342174	
6	PCB IO 2040	324145	
7	Ethernet switch – 8 port	343253	
	Ethernet switch – 5 port	307828	

Configuration list			
Product: EM 2040 Processing Unit		*Registration number:*	
		Serial number:	
Item	*Equipment*	*Registration number*	*Serial number*
1	PCB CPU Processor Unit	340372	
2	PCB BSP 67B-1 Signal processor	342174	
3	PCB BSP 67B-2 Signal processor	342174	
4	PCB BSP 67B-3 Signal processor	342174	
5	PCB BSP 67B-4 Signal processor	342174	
6	PCB IO 2040	324145	
7	Ethernet switch – 8 port	343253	
	Ethernet switch – 5 port	307828	

Configuration list			
Product: EM 2040 Processing Unit		*Registration number:*	
		Serial number:	
Item	*Equipment*	*Registration number*	*Serial number*
1	PCB CPU Processor Unit	340372	
2	PCB BSP 67B-1 Signal processor	342174	
3	PCB BSP 67B-2 Signal processor	342174	
4	PCB BSP 67B-3 Signal processor	342174	
5	PCB BSP 67B-4 Signal processor	342174	
6	PCB IO 2040	324145	
7	Ethernet switch – 8 port	343253	
	Ethernet switch – 5 port	307828	

6 INTERCONNECTION/ARRANGEMENT

The system shall be installed and external sensors shall be connected.

7 TEST PROCEDURE

Switch on power to the Operator station and to the Processing Unit. Perform all tests as described in the Check List and fill in the results for each individual test.

8 CHECK LIST

Check list

Pos	*Test operation*	*Result*		*Specification*
		PreHAT	*HAT*	
1	Start the SIS operator software and select the EM 2040 Processing Unit (PU)	OK	OK	The SIS is started and contact with the Transceiver unit PU is established.
2	Start internal test. Execute the following BIST (Built in system tests), one by one.			Verify successful completion of the tests.
	CPU Test	OK	OK	✓
	~~BSP~~ Test CBmF	OK	OK	✓
	~~IO 2040 Test~~ RX - CPU LINK	OK	OK	✓
	RX unit test	OK	OK	✓
	TX unit test	OK	OK	✓
	~~IO 2040-BSP~~ link CBmF - CPU	OK	OK	✓
	RX unit~~-BSP~~ link CBmF	OK	OK	✓
	RX Channels	OK	OK	✓
	TX channels via RX	OK	OK	✓

Check list

Pos	*Test operation*	*Result*		*Specification*
		PreHAT	*HAT*	
	RX Noise Level (dB):			Document the average NL
	200 kHz	47.4	47.4	✓
	300 kHz	45.4	45.4	✓
	380 kHz	45.8	45.8	✓
	RX Noise Spectrum:			
	200 kHz	47.5	47.5	✓
	300 kHz	45.7	45.7	✓
	380 kHz	46.3	46.3	✓
	Software Date/Version:			Fill in date/version:
	CPU	OK	OK	2.2.2 161215
	~~BSP~~ CBMF	OK	OK	1.11 18.02.20
	~~IO 2040~~ DDS	OK	OK	4.6 140106
	RX Transducer Unit #1	OK	OK	1.02 12NOV2012
	RX Transducer Unit #2	–	–	N/A
	TX Transducer Unit	OK	OK	1.07 8 MAR 2018
	System info	NA	NA	

Check list				
Pos	Test operation	Result		Specification
		PreHAT	HAT	
3	Test of serial port 1. Set the installation parameters for the serial port 1 to match the connected sensor, and make this port the active one.	OK	OK	At the Operator Station Numerical display, verify that the sensor fields changes from red to white and that the sensor values are updated.
4	Test of serial port 2. Set the installation parameters for the serial port 2 to match the attitude sensor, and make this port the active one.	OK	OK	At the Operator Station Numerical display, verify that the attitude fields changes from red to white and that the attitude is updated
5	Test serial port 3 if a sensor is connected to this port. Set the installation parameters for the serial port 3 to match the sensor, and make this port the active one.	OK	OK	At the Operator Station Numerical display, verify that the sensor fields changes from red to white and that the sensor values are updated.
6	Test ping mode Fill inn the installation parameters and start pinging. A position simulator may be used to make the ship move around in the geographical display.	OK	OK	Verify the functionality of the cross track displays, the waterfall display, the seabed image display and the geographical display. Verify that the coverage sector can be adjusted.
7	Water column display Start the water column display.	OK	OK	Verify the display of the water column data.
8	Test of printer. If a printer is included in the delivery, transfer a file to the printer.	N/A	N/A	Verify the print of the file (picture) transferred from the Operator Station.
9	Test of sound speed probe. If a probe is connected to the multibeam, check the interface to the probe.	OK	OK	Verify that the sound speed is displayed on the Operator Station.

Check list				
Pos	*Test operation*	*Result*		*Specification*
		PreHAT	*HAT*	
10	1pps Input	OK	OK	
11				
12				

Performed by (date/sign)	**Witnessed by (date/sign)**
PreHAT:	*PreHAT:*
HAT: GREGG JUERGENS 5/21/18	*HAT:* SAMUEL GREENAWAY LCDR/NOAA 5/21/18

9 TESTIMONIAL

NOAA THOMAS JEFFERSON

The HARBOUR ACCEPTANCE TEST for the EM 2040, for LAUNCH # 2903 has been performed according to the test procedure.

The test is: **[✓ Accepted]** / **Not accepted** *(Delete as appropriate)*

Remarks:

All ops Normal

Please use capital letters:

Test performed by	Position	Company
CORELL JUERGENS	FIELD TECH	Kongsberg Maritime
Test accepted by	**Position**	**Company**
SAMUEL GREENAWAY	Chief, HSTB	NOAA

Date	Signature
5/21/2018	
5/21/2018	

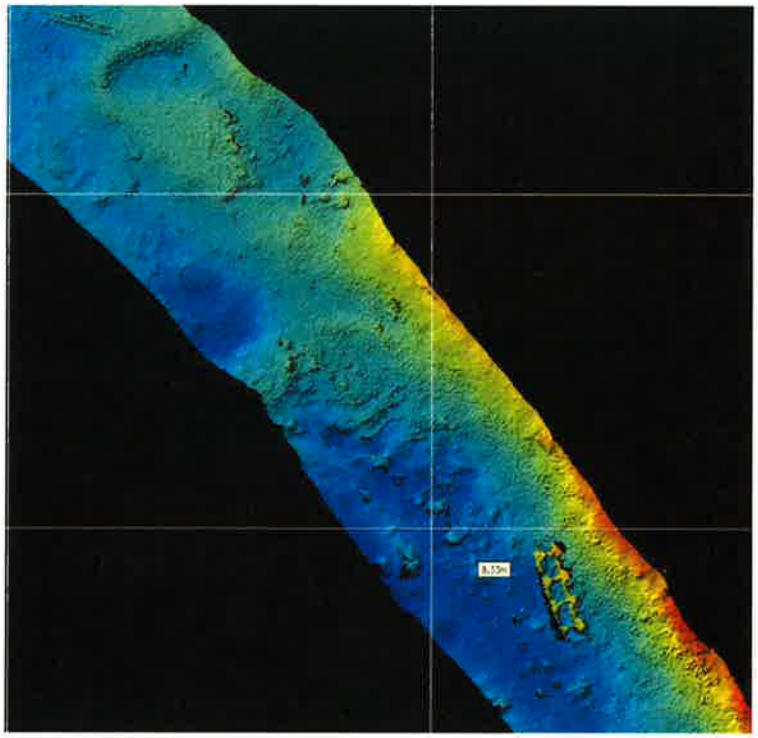
KONGSBERG

Sea Acceptance Test

T. J. LAUNCH
* 2903

EM 2040

Multibeam Echo Sounder



Document history

Document number	353054	
Rev A	*December 2010*	

Contents

1 INTRODUCTION

The purpose of this procedure is to verify that the system as installed is fully functional at sea, and to serve as a step by step record of the successful completion of the Sea Acceptance Test. It is to be followed to verify correct functioning of the multibeam echo sounder and the various external sensors or systems as an integrated mapping system. It will also verify that the system interfaces and peripherals are functional.

The sea trials shall establish:

- that the different EM 2040 units work properly at sea
- that the heave, roll and pitch signals are correctly used
- that the heading signal is correctly used
- that the sound speed input data are correctly used
- that the positioning system data are correctly used
- that the system is capable of providing good depth data consistently
- that the system during operation produces digital data to its internal storage devices and, if available, to an external logging system connected via Ethernet

The Sea Acceptance Test shall consist of a verification of correct interfacing of external sensors, a calibration of external sensor offsets and time delays, a test survey, and assessment of the data from the test survey. In addition, as far as time and external conditions allow, limitations on system performance as a function of water depth, vessel speed and sea state shall be established.

2 REFERENCES

Factory and Harbour Acceptance Test records.

3 TEST EQUIPMENT

No special test equipment is required for the Sea Acceptance Test, but all sensors normally needed for surveying with a multibeam echo sounder shall be available.

4 LIST OF ITEMS

The items, which are to be tested, will depend on the particular configuration. Use the manufacturer type number column to indicate which items are actually included in this particular delivery or furnished by the owner to be used with the system.

These are the items to be tested:

Item	*Registration Number*	*Equipment*	*Serial number*
1	419322	HWS Operator Station	CZC746864F/ 1212
2	385412	EM 2040 Processing Unit	40143
3	338211	TX transducer unit	281
4	338214	RX transducer unit	392 —
5	SBE 19plus	Sound Speed Profile Sensor	19P33589-4487
6	IMU-200 10001506	Motion Sensor	131
7	POS-MV PCS-84	Heading sensor	8927
8	RESON SVP71	Fixed Sound Speed Sensor	N/A
9			

5 CONFIGURATION

The modules and circuit boards included in the system and their serial numbers were noted in the Factory and Harbour Acceptance tests. Any replacement modules or circuit boards since the HAT must be noted.

Replacement list

Item	*Equipment*	*Registration number*	*Serial number*
1			
2			
3			
4			
5			
6			
7			

6 SOFTWARE

The system software version must be noted, including the subsystems, and reflecting any changes made during the trials.

Item	*Equipment*	*Version number*	*Version date*
1	Operator Station	4.32	FEB 24 2016
	Processing Unit (PU):		
2	CPU	2.2.2	16 12 15
3	~~BSP~~ master CBMF	1.11	18 02 20
4	~~BSP~~ slave CBMF	1.11	18 0220
5	~~IO 2040~~ DDS	4.6	140 106
6	RX Transducer Unit # 1	1.02	NOV 12 2012
7	RX Transducer Unit # 2	—	—
8	TX Transducer Unit	1.07	MAR 8 2018

7 INTERCONNECTION / ARRANGEMENT

The system shall have been installed according to the Instruction Manual.

Note the locations of the transducers, motion sensor(s) and positioning system(s) as entered on the Operator Station:

	X (forward pos)	*Y (starboard pos)*	*Z (downwards)*
TX Transducer Unit			
RX Transducer Unit # 1	-0.100	-0.305	-0.016
RX Transducer Unit # 2			
Motion sensor no 1			
Motion sensor no 2			
Positioning system no 1			
Positioning system no 2			
Positioning system no 3			
Pos. system Ethernet			
Waterline downward			

TX IS REF
NUMBERS REFLECT
RX RELATIVE TO TX

~~RX TX REF TO RX~~

Note the transducer alignment angles as entered on the Operator Station:

	Roll	*Pitch*	*Heading*
TX Transducer Unit			
RX Transducer Unit # 1			
RX Transducer Unit # 2			

8 TEST PROCEDURE

The test will be documented through the tables on the following pages. The tests shall generally be done in the following order:

- Interface tests
- Calibration
- Survey
- Data assessment

Assessment of the survey data collected should preferably be done on board.

Note that the noise measurements and test of performance with regard to depth and/or sea state are to be run in the order which best suits the conditions during the test period. It is not expected that many different conditions will be encountered during the limited time available for the sea acceptance test. However, it is strongly advised that when different conditions are encountered during later use of the system, the system performance as a function of external conditions is noted, for example in this record. This will be valuable for later use in survey planning and in ensuring the most efficient use of the system.

8.1 Test of Interfaces

Tests of the external sensor interfaces should have been run during the Harbour Acceptance test. However, these tests were necessarily limited (static), as only performed along the key side. Thus the data from the external sensors should be observed on the system display during vessel maneuvering, and verified for correctness (positions and clock) or correct sign and/or reasonable magnitude (heave, roll, pitch, heading and sound speed).

During the test data will be logged, all connected hard-copy devices should be employed, and sound speed profiles loaded into the system. Observe that this is functional. Fill in the table below to record this.

Test no.	*Function to be tested*	*Test result*	*Notes*
1	Position input	OK	GGK
2	External clock input	OK	ZDA
3	Transducer depth sound speed input	OK	SVSS
4	Sound speed profile input	OK	IMPORTED VIA ETH
5	Heading input	OK	Em3600
6	Motion data input	OK	EM3000
7	Data output to internal storage	OK	
8	Data output to external storage	N/A	
9	Data output to external Ethernet	OK ~~N/A~~	OUT TO HYPAK
10	Postscript printer	N/A	
11	Printer/plotter/recorder output	N/A	

8.3 Sensor Offset/Calibration

The offset or zero bias of the roll, pitch and heading sensors and the time delay of the position system(s) are to be measured or estimated before leaving port if possible (this is especially important with regard to the heading sensor). A calibration of these offsets shall be performed at sea as the second part of the test in accordance with the procedures given in the Operator Manual. Finally, these offsets shall be estimated from the final test survey. Fill in the table below with the offsets as entered into the Operator Station:

	Port Estimate	Calibration result	Final Estimate
Roll offset system 1		0.14	0.14
Roll offset system 2		~~0.25~~	X
Pitch offset system 1		-0.25	-0.25
Pitch offset system 2		—	—
Heading offset system 1		-1.54	-1.54
Heading offset system 2		—	—
Position time delay system 1		—	8ms
Position time delay system 2		—	—
Position time delay system 3		—	—

THESE ENTERED W/ OPPOSITE SIGN IN POS-MV 'REF TO IMU' ANGLES.

ENTERED INTO SIS ATTITUDE DELAY

Note the positioning system type used during the sea acceptance test and its estimated accuracy:

	Positioning system type	Estimated accuracy for position system
Pos system 1	Pos-mV	>20cm
Pos system 2		
Pos system 3		

8.4 Survey

The integrity of the total survey system consisting of the multibeam echo sounder as installed on the vessel, motion sensor, heading sensor, sound speed sensor(s), and positioning system(s) shall be assessed by doing a survey of a limited area and inspecting the collected data. The result should be compared against the specified accuracy of the echo sounder, taking into account the precision of the external sensors, and any limitations imposed by the vessel and its handling. Note that this test is **not** designed to measure the accuracy of the echo sounder itself, as this would require a much more extensive test period, and has been done on previous system installations.

The sea acceptance test's main part will be a sensor calibration followed by a system assessment survey in the calibration area. The area used for the sea trials should thus consist at least partly of a relatively flat bottom and partly of a significant slope as required for a calibration in accordance with the guidelines for calibration as given in the Operator Manual. In case this is not possible the calibration of the various sensors must be run in separate areas while the final assessment survey should be run in the flat part used for roll calibration. The depth should then ideally be in the 10-30 m range (not critical).

Five parallel lines should be run with a line spacing equal to about one quarter of the achieved coverage in the actual area. Neighboring lines should be run in opposite directions. The line length should be in the order of twice the achieved coverage. A sixth line should be run perpendicular to and across the five previous lines.

Assess the data with the system's grid display using a grid cell size giving about 10-20 soundings per cell. Using the various display options, investigate the frequency and magnitude of outliers, discrepancies between lines, and depth differences within cells. Use also the calibration profile displays to assess any remaining errors due to roll offset or sound speed profile problems. If the performance of the system is not according to expectation, describe the results in the Comment section below, otherwise note that the system performance is accepted. Any un-resolvable performance problems should be further investigated and quantified with a post-processing system.

Note the area with positions and depths where the Customer Acceptance Test has been performed:

SAT area: SACKETT BANK

SAT position: 28° 38' 14.3724N 89° 33' 44.0005 W

SAT depth: 50 - 100m

8.5 Sea Conditions Performance Assessment

SEE SEPARATE NOISE TESTING DOCS.

During the sea acceptance test, the performance of the whole system shall be assessed. The important factors limiting achievable accuracy and coverage are noise, sea temperature and salinity and sea state. With heavy seas it is to be expected that the performance will also depend upon vessel heading with respect to wave direction. On some vessels the noise level at particular speeds and propeller revolutions may also affect coverage. It is recommended to assess achieved coverage as a function of environmental parameters both during the sea acceptance test and later operation. The results should be entered in the table below, both to document conditions during the test and later to have a record of the system's performance according to external conditions.

The noise experienced by the system may be measured from the Operator Station as described in the Operator Manual. Several measurements should be taken and the result averaged before noting it in the table below:

Date	*Depth (m)*	*Sea State*	*Heading Against Waves*	*Speed*	*RPM*	*Noise*	*Comments*

The coverage is assessed by observing the swath width on the Operator Station on a reasonably flat bottom. The average of several pings and any occurrence of missed pings should be noted in the table below:

Date	*Depth (m)*	*Sea State*	*Heading Against Waves*	*Speed (kn)*	*RPM*	*Abs. coeff.*	*Coverage (m)*	*Missing Pings, Comments*
5/22	70	1-2	↘	7.5	1105		389	
	64		↘	7.5	1105		392	
	80		↖	7.5	1105		432	
	92		→	.5	750		453	
	64		↗	8	1232		376	
	96		→	9.5	1580		395	
	112	1-2	↘	13	1961		277	TRANSIT TO EXTECT AREA - NOISY!
5/23	24	2	↘	.5	750		160	DIW 75x75
	24	2	↘	8	1275		97	60 x 60
	24	2	↖	7.5	1200		124	SONAR PADDLE
	24	2	↖	9	1400		124	

Performed by (date/sign)	**Witnessed by (date/sign)**
PreSAT: 5/22/18	*PreSAT:*
SAT: Brett Juergens 5/22/18	*SAT:* LCDR Samuel Greenaway, NOAA 5/23/18

9 TESTIMONIAL

The SEA ACCEPTANCE TEST for the EM 2040, for THOMAS JEFFERSON LAUNCH 2903 has been performed according to the test procedure.

This SAT approval is only valid if the test is performed by an engineer certified by Kongsberg Maritime A/S.

The test is: [✓ **Accepted**] / **Not accepted** *(Delete as appropriate)*

Remarks:

① INVESTIGATING NOISE TO STARBOARD SIDE OF NADIR.
A) VERY EVIDENT @ 200KHZ - SHORT CW
B) SWITCHING DUAL SWATH OFF APPEARS TO ALLEVIATE NOISE.
C) WILL FOLLOW UP W/ NORWAY AND PROVIDE INFO TO VESSEL.
D) FOR FURTHER INFO SEE TRIP REPORT

Please use capital letters:

Test performed by	Position	Company
GREG JUERGENS	FIELD TECH	Kongsberg Maritime
Test accepted by	**Position**	**Company**
SAMUEL GREENAWAY	CHIEF, HSTB	NOAA, OCS

Date	Signature
5/27/18	
5/23/18	

Kongsberg Underwater Technology, Inc.
19210 33rd Ave West Suite A
Lynnwood, WA 98036, USA.
Tel. (425) 712-1107, Fax (425) 712-1197
Support: km.support.lynnwood@kongsberg.com
Km.hydrographic.support@kongsberg.com
Support World Wide (Norway) +47 815 35 355

Service Report

CUSTOMER: **NOAA**	**VESSEL/FACTORY/SITE:** **Thomas Jefferson Launches 2903 & 2904**	**DATE:** 5/17/2018 – 5/24/2018
LOCATION: Pascagoula, MS – Galveston, TX.	**ENGINEER/Technician** Gregg Juergens	**SERIAL/FILE No:** n/a
WORKORDER / PO: **WO01070**	**ACCOUNT/PROJECT No:** n/a	**CONTRACT No:** n/a

EQUIPMENT DELIVERED/INSTALLED/REPLACED.

QTY	Part Desc.	Part No.	Serial No.	Comments.

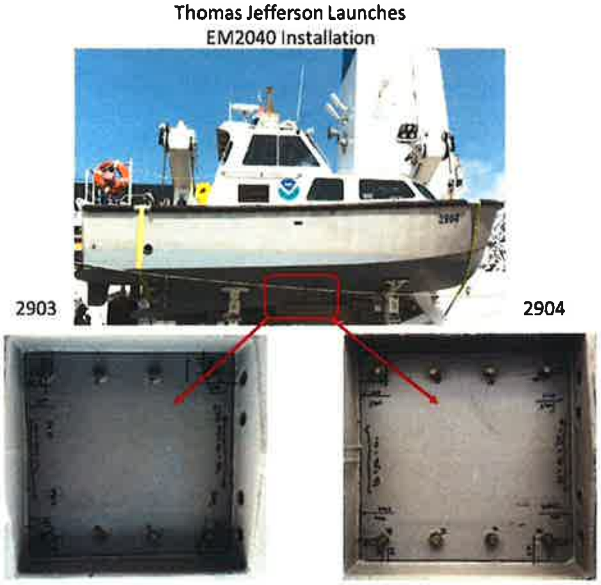
1. Main Purpose of Visit –

- Install EM2040 system on TJ's Launches (2ea)
- Perform HAT on systems
- Perform SAT on systems

2. Overview –

- **5/17/2018** 8Hrs
  - Travel Day, Seattle, WA to Pascagoula, MS

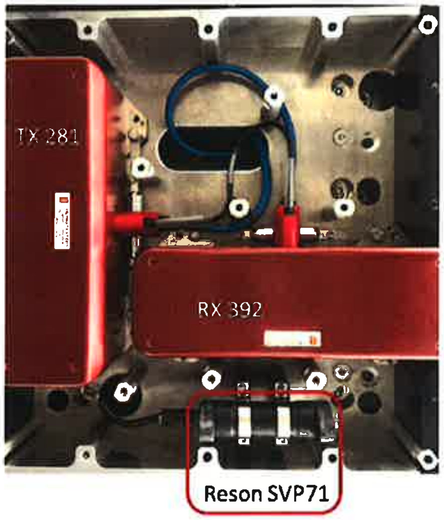
- **5/18/2018** 10Hrs
  - Arrive to vessel 0845
  - Perform cursory inspection of Hull where EM2040 casing will be mounted



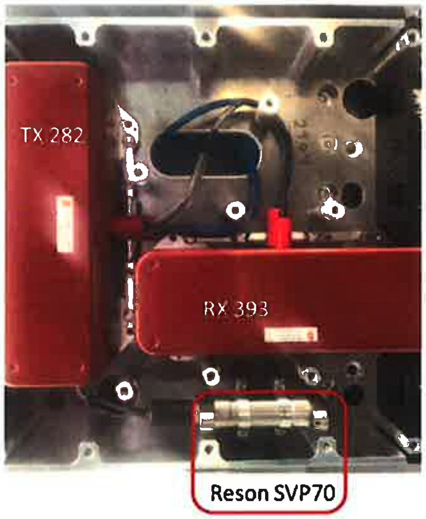
- Discuss plan with crew regarding EM2040 installation
- Equipment arrived to facility aprox 11:00
    - Divided up equipment per vessel
    - Installed Wheel House equipment into racks on both Launches
        - SIS Work Station
        - EM2040 PU
        - Installed cabling for these pieces

- **5/19/2018** 12Hrs
    - Installed casings and transducers on both Launches

2903



2904



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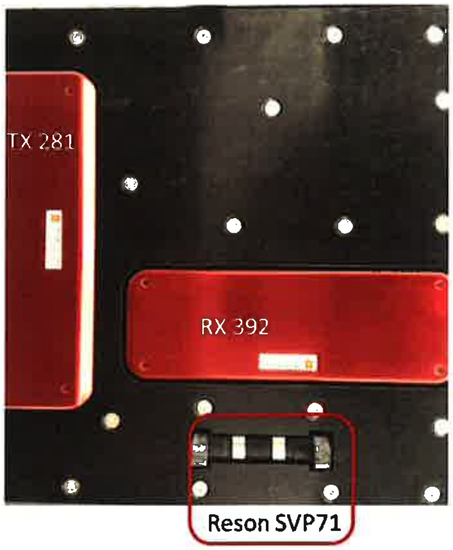

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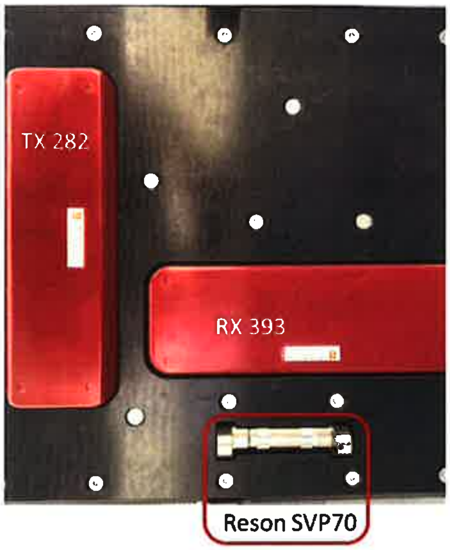
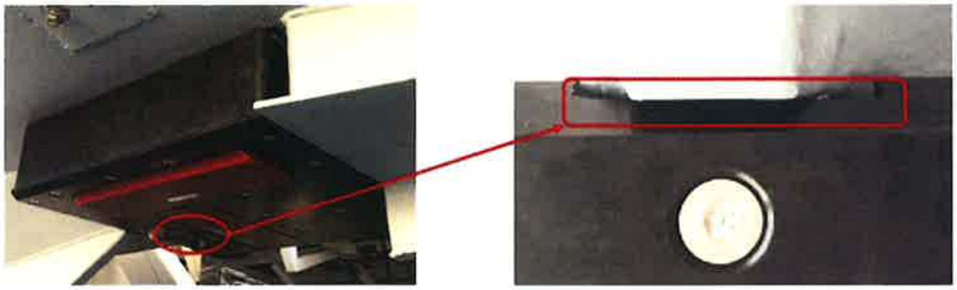
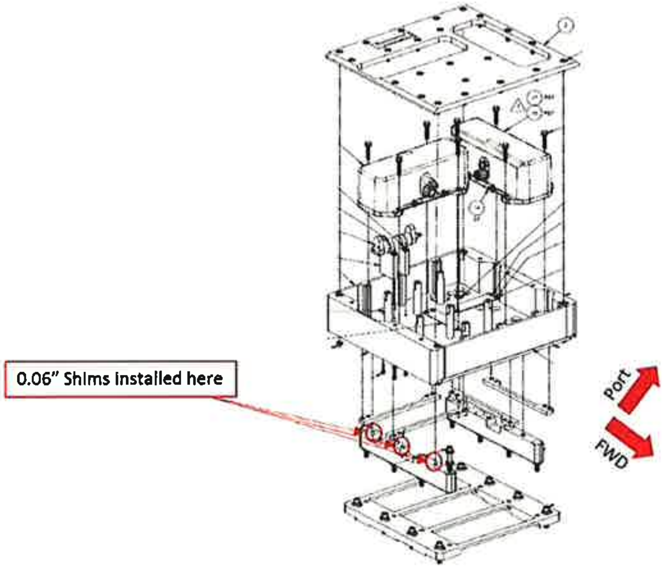


- On Launch 2903 forward port Heli coil was bad, removed and inserted new Heli coil – was only able to obtain a Heli coil half as long (3/4") as what was orig installed –
- On Both Launches modified cover plate to allow for fit



- On Launch 2904 installed 0.06" shims on Starboard support strut to have cover plate sit flush with hull fairing

2904



- **5/20/2018** 12Hrs
  - Finish terminating/connecting system cables inside launches
  - Configure Installation settings for data inputs into PU's
    - COM1, 19200, 8, 1, None (RS232)
      - GGK and ZDA
    - COM2, 19200, 8, 1, None (RS232)
      - Attitude, EM3000
    - UDP5
      - Attitude Velocity
      - 129.100.1.230 : 5602
    - On Launch 2903 Input Lever arms for RX to TX. All other lever arms applied in POS-MV. POS-MV is outputting valid data at TX Head
      - RX
        - X -0.100
        - Y -0.305
        - Z -0.016

- **5/21/2018** 12Hrs
    - Terminated Reson SVS's on each Launch as follows

Launch 2903

SVP 71 confioguration on Launch **2903**			
6 Pin Connector	Color	Discription	SVS J-Box
1	Black	Com's Gnd	TB5
2	White	TX	TB3
3	Brown	RX	TB4
4	Green	Power 12+	TB1
5	n/a	n/a	n/a
6	Blue	Power Gnd	TB2

Launch 2904

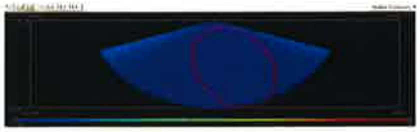
SVP 70 Configuration on aunch **2904**			
9 Pin Connector	Color	Description	SVS J-Box
Shield	Screen	Com's Gnd	TB5
1	n/a	n/a	n/a
2	Black	RX	TB4
3	White	TX	TB3
4	n/a	n/a	n/a
5	n/a	n/a	n/a
6	n/a	n/a	n/a
7	n/a	n/a	n/a
8	Brown	Power Gnd	TB2
9	Orange	Power 12+	TB1

        - Tested both Reson SVS's - all op's appear normal
        - Configured on both Launches - SIS External input to accept on COM1
            - 9600, 8, 1, & none
            - Set Sensor selection to AML SV
    - Performed HAT on Launch 2903 since it was on outside of vessel. 2904 will have to wait until we get out seeing we could not drop into water due to it being pier side
        - HAT results for 2903 all OK
            - Performed BIST – all Pass
                - REF files;
                  <HAT_BIST_21May2018.txt>
                  <HAT_SystemReport_PU40143_RX392_TX281_20180521_212611>
            - Saved PU Parameter file Post HAT
                - REF file <Post_HAT_Config_21May2018>
    - Departed pier 1630 for initial test site
    - Discovered 2904 full of water in cab, up to floor grating in cab.
        - Further investigation by engineers on board found AC suction hose had come loose. This allowed engine compartment to fill completely flooding Generator, Batteries etc. Due to this 2904 will not be able to be tested during this trial.

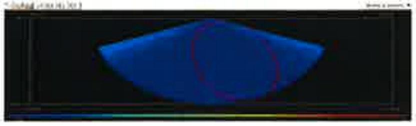
- **5/22/2018** 12Hrs
    - Arrived to test site
    - Vessel deployed Launch aprox 0830
    - Arrived to SAT Cal site
        - Performed Calibration per NOAA requirements using their method
            - Performed Post Cal BIST <SAT_BIST_22May2018 >
        - Performed noise tests at varying speeds etc., see attached file
        - Performed additional noise tests, system put into 'Sonar Passive' Mode and collected varying data at different speeds. This was for NOAA information only.
            - During these tests noted when system set for 200Khz and using Short CW there was noise just to Starboard of Nadir, when selecting another Pulse Mode, IE: Medium, Long or FM the noise either faded or was not present see below->

Short CW 200Khz

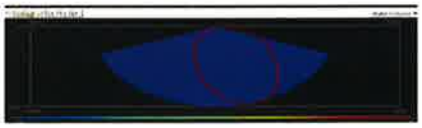
Medium CW 200Khz



Long CW 200Khz



FM 200Khz



      - Performed additional trouble shooting, IE: Power up down other equipment, have vessel go dead in water with the exception of UPS and Generator, no change-
    - Transited back to TJ and was recovered.
      - Will trouble shoot more tomorrow when on Reference Surface site
- **5/23/2018** 12Hrs
  - Vessel arrived to "Reference Surface" site
  - Deployed Launch 2903
  - Ran Ref Surface survey
  - Performed additional trouble shooting on noise seen at 200Khz Short CW
    - Isolated PU
    - Powered down vessel completely so EM2040 only running on Batteries from UPS, noise still present
    - Swapped out PU for one that was installed on Launch 2904, noise still present
    - Further testing showed that noise appears to be affected by-> Pulse Mode selected, Dual Swath on / off, Frq selected – 200, 300 or 400
    - Am leaving system as is for now. Once other launch is operational will compare.
      - Am suggesting to bring an additional RX and TX cable for testing purposes
  -

3. Software Details –

- TJ Launch 2903
  - SIS Version 4.32
- TJ Launch 2904
  - SIS Version 4.32

4. Summary –

- NOAA Launch 2904
  - Installation of EM2040 completed
  - System has not been tested, No HAT or SAT performed yet due to flooding
  - Vessel to schedule another time after Launch is corrected for us to return to perform HAT and SAT before using for operations.
  - System was powered up prior to flooding to verify operations. At that time all looked OK

    * EM2040 TOPSIDE EQUIPMENT DID NOT GET WET.
- NOAA Launch 2903
  - Installation of EM2040 completed
  - System has been tested, HAT and SAT performed and accepted.
    - Noise on Starboard side is still being looked into. Will revert after discussing with Norway further
    - Will need to compare against Launch 2904 when it is operational
    - Calibrated numbers applied to system
    - Ref Surface performed, discovered 8ms timing error
      - Applied this to system
      - Took PU back up at this time
        - < Post_SAT_Config_23May2018 >
- Provided temporary connections drawing for both Launches

5. Signatures.

DATE: *5/23/2018*	*KM Represéntitive signature:* *Printed: Gregg Juergens*	*Work Accepted on behalf of Customer signature:* *Printed:* SAMUEL GREENAWAY

Customer NOAA	Vessel/Factory/Site Thomas Jefferson Launches 2903 & 2904	Serial no. n/a
Employee no. JUER001	Service Engineer Gregg Juergens	Page 3 of 3
Location Pascagoula, MS – Galveston, TX	Account no./Job no. WO#01070	Week no.

Day/ date	Off-shore	Description	Time from/to	Norm time	Time diff.
5/17/2018		Travel Day		8	
5/18/2018		Work on vessel pier side		10	
5/19/2018		Work on vessel pier side		12	
5/20/2018	XX	Work on ~~Vessel off shore~~ - PIERSIDE		~~12~~ 10	
5/21/2018	XX	Work on Vessel off shore -		12	
5/22/2018	XX	Work on Vessel off shore -		12	
5/23/2018	XX	Work on Vessel off shore -		12	
5/24/2018	XX	Work on Vessel off shore -		12	
5/25/2018		Travel Day		8	

Date 5/23/2018	Kongsberg representative signature	Work accepted on behalf of customer	Working lime		
		Printed SAMUEL GREENAWAY	Waiting time		
		Signature	Traveling time		

Service provided by: Kongsberg Underwater Technology, Inc.

Kongsberg Underwater Technology, Inc.
19210 33rd Avenue West, Suite A
Lynnwood, WA 98036-4707
425-712-1107 (tel)
425-712-1197 (fax)

Service	On board______	In shop____
Repair & return	Yes_______	No_______
Guarantee	Yes_______	No_______

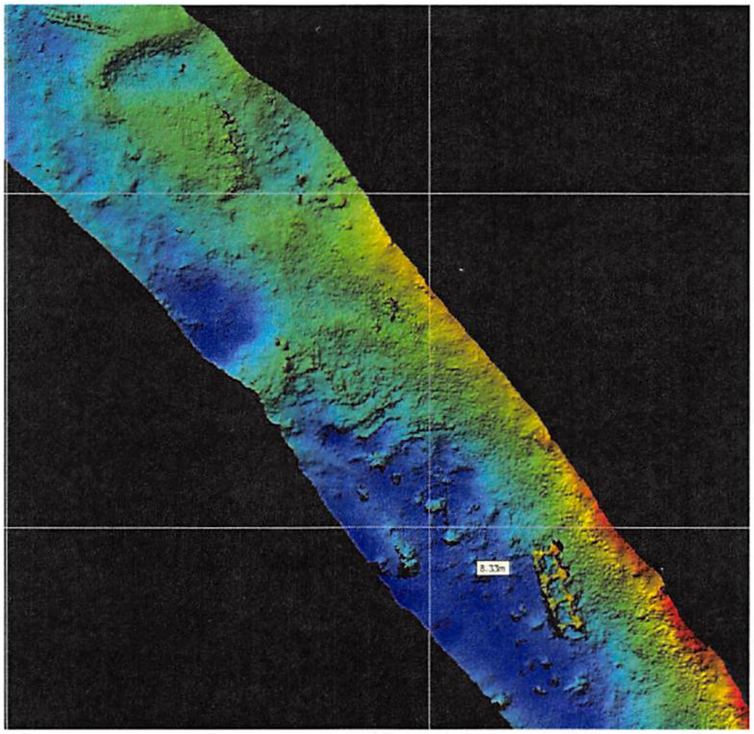
THOMAS JEFFERSON
LAUNCH # 2904

KONGSBERG

Sea Acceptance Test

EM 2040

Multibeam Echo Sounder



Document history

Document number	353054	
Rev A	*December 2010*	

Contents

1 INTRODUCTION

The purpose of this procedure is to verify that the system as installed is fully functional at sea, and to serve as a step by step record of the successful completion of the Sea Acceptance Test. It is to be followed to verify correct functioning of the multibeam echo sounder and the various external sensors or systems as an integrated mapping system. It will also verify that the system interfaces and peripherals are functional.

The sea trials shall establish:

- that the different EM 2040 units work properly at sea
- that the heave, roll and pitch signals are correctly used
- that the heading signal is correctly used
- that the sound speed input data are correctly used
- that the positioning system data are correctly used
- that the system is capable of providing good depth data consistently
- that the system during operation produces digital data to its internal storage devices and, if available, to an external logging system connected via Ethernet

The Sea Acceptance Test shall consist of a verification of correct interfacing of external sensors, a calibration of external sensor offsets and time delays, a test survey, and assessment of the data from the test survey. In addition, as far as time and external conditions allow, limitations on system performance as a function of water depth, vessel speed and sea state shall be established.

2 REFERENCES

Factory and Harbour Acceptance Test records.

3 TEST EQUIPMENT

No special test equipment is required for the Sea Acceptance Test, but all sensors normally needed for surveying with a multibeam echo sounder shall be available.

4 LIST OF ITEMS

The items, which are to be tested, will depend on the particular configuration. Use the manufacturer type number column to indicate which items are actually included in this particular delivery or furnished by the owner to be used with the system.

These are the items to be tested:

Item	*Registration Number*	*Equipment*	*Serial number*
1	419322	HWS Operator Station	1205
2	385412	EM 2040 Processing Unit SCIDa 90	40139
3	338211	TX transducer unit	282
4	338214	RX transducer unit	393 –
5	SBE 19 plus	Sound Speed Profile Sensor	19P60744-6667
6	IMU-200 1000 1504	Motion Sensor	356
7	~~Reson~~ ~~SVP70~~	Heading sensor IMU-200/POS-MV	N/A
8	Reson SVP70	Fixed Sound Speed Sensor	N/A
9			

5 CONFIGURATION

The modules and circuit boards included in the system and their serial numbers were noted in the Factory and Harbour Acceptance tests. Any replacement modules or circuit boards since the HAT must be noted.

Replacement list			
Item	*Equipment*	*Registration number*	*Serial number*
1			
2			
3			
4			
5			
6			
7			

6 SOFTWARE

The system software version must be noted, including the subsystems, and reflecting any changes made during the trials.

Item	*Equipment*	*Version number*	*Version date*
1	Operator Station	4.3.2	FEB 24 2016
	Processing Unit (PU):		
2	CPU	2.2.2	16 12 15
3	~~BSP master~~ CBMF	1.11	18 02 20
4	~~BSP slave~~ Vx Works	6.9	Nov 23 2015
5	IO ~~2040~~	/	/
6	RX Transducer Unit # 1	1.02	Nov 12 2012
7	RX Transducer Unit # 2	n/a	n/a
8	TX Transducer Unit	1.07	MAR 8 2018

7 INTERCONNECTION / ARRANGEMENT

The system shall have been installed according to the Instruction Manual.

Note the locations of the transducers, motion sensor(s) and positioning system(s) as entered on the Operator Station:

	X (forward pos)	*Y (starboard pos)*	*Z (downwards)*
TX Transducer Unit	0	0	0
RX Transducer Unit # 1	-0.1	-0.305	-0.016
RX Transducer Unit # 2	—	—	—
Motion sensor no 1	—	—	—
Motion sensor no 2	—	—	—
Positioning system no 1	—	—	—
Positioning system no 2	—	—	—
Positioning system no 3	—	—	—
Pos. system Ethernet	—	—	—
Waterline downward	—	/	-0.694

Note the transducer alignment angles as entered on the Operator Station:

	Roll	*Pitch*	*Heading*
TX Transducer Unit	0	0	0
RX Transducer Unit # 1	0	0	0
RX Transducer Unit # 2	0	0	0

8 TEST PROCEDURE

The test will be documented through the tables on the following pages. The tests shall generally be done in the following order:

- Interface tests
- Calibration
- Survey
- Data assessment

Assessment of the survey data collected should preferably be done on board.

Note that the noise measurements and test of performance with regard to depth and/or sea state are to be run in the order which best suits the conditions during the test period. It is not expected that many different conditions will be encountered during the limited time available for the sea acceptance test. However, it is strongly advised that when different conditions are encountered during later use of the system, the system performance as a function of external conditions is noted, for example in this record. This will be valuable for later use in survey planning and in ensuring the most efficient use of the system.

8.1 Test of Interfaces

Tests of the external sensor interfaces should have been run during the Harbour Acceptance test. However, these tests were necessarily limited (static), as only performed along the key side. Thus the data from the external sensors should be observed on the system display during vessel maneuvering, and verified for correctness (positions and clock) or correct sign and/or reasonable magnitude (heave, roll, pitch, heading and sound speed).

During the test data will be logged, all connected hard-copy devices should be employed, and sound speed profiles loaded into the system. Observe that this is functional. Fill in the table below to record this.

Test no.	*Function to be tested*	*Test result*	*Notes*
1	Position input	OK	GGK
2	External clock input	OK	ZDA
3	Transducer depth sound speed input	OK	SSVS
4	Sound speed profile input	OK	INPUT VIA ETH
5	Heading input	OK	EM3000
6	Motion data input	OK	EM3000
7	Data output to internal storage	OK	
8	Data output to external storage	N/A	
9	Data output to external Ethernet	OK ~~N/A~~	OUTPUT TO HYPAK
10	Postscript printer	N/A	
11	Printer/plotter/recorder output	N/A	

8.3 Sensor Offset/Calibration

The offset or zero bias of the roll, pitch and heading sensors and the time delay of the position system(s) are to be measured or estimated before leaving port if possible (this is especially important with regard to the heading sensor). A calibration of these offsets shall be performed at sea as the second part of the test in accordance with the procedures given in the Operator Manual. Finally, these offsets shall be estimated from the final test survey. Fill in the table below with the offsets as entered into the Operator Station:

	Port Estimate	Calibration result	Final Estimate
Roll offset system 1	–	0.256	0.256
Roll offset system 2	–	–	–
Pitch offset system 1	–	0.118	0.118
Pitch offset system 2	–	–	–
Heading offset system 1	–	0.076	0.076
Heading offset system 2	–	–	–
Position time delay system 1	–	6 ms	6 ms
Position time delay system 2	–	–	–
Position time delay system 3	–	–	–

THESE VALUES ENTERED INTO POS-MV W/ OPPOSITE SIGN.

Note the positioning system type used during the sea acceptance test and its estimated accuracy:

	Positioning system type	Estimated accuracy for position system
Pos system 1	POS-MV	> 20 cm
Pos system 2	N/A	
Pos system 3	N/A	

8.4 Survey

The integrity of the total survey system consisting of the multibeam echo sounder as installed on the vessel, motion sensor, heading sensor, sound speed sensor(s), and positioning system(s) shall be assessed by doing a survey of a limited area and inspecting the collected data. The result should be compared against the specified accuracy of the echo sounder, taking into account the precision of the external sensors, and any limitations imposed by the vessel and its handling. Note that this test is not designed to measure the accuracy of the echo sounder itself, as this would require a much more extensive test period, and has been done on previous system installations.

The sea acceptance test's main part will be a sensor calibration followed by a system assessment survey in the calibration area. The area used for the sea trials should thus consist at least partly of a relatively flat bottom and partly of a significant slope as required for a calibration in accordance with the guidelines for calibration as given in the Operator Manual. In case this is not possible the calibration of the various sensors must be run in separate areas while the final assessment survey should be run in the flat part used for roll calibration. The depth should then ideally be in the 10-30 m range (not critical).

Five parallel lines should be run with a line spacing equal to about one quarter of the achieved coverage in the actual area. Neighboring lines should be run in opposite directions. The line length should be in the order of twice the achieved coverage. A sixth line should be run perpendicular to and across the five previous lines.

Assess the data with the system's grid display using a grid cell size giving about 10-20 soundings per cell. Using the various display options, investigate the frequency and magnitude of outliers, discrepancies between lines, and depth differences within cells. Use also the calibration profile displays to assess any remaining errors due to roll offset or sound speed profile problems. If the performance of the system is not according to expectation, describe the results in the Comment section below, otherwise note that the system performance is accepted. Any un-resolvable performance problems should be further investigated and quantified with a post-processing system.

Note the area with positions and depths where the Customer Acceptance Test has been performed:

SAT area: OFF OF GALVESTON, TX

SAT position: N 28 83811 W 93.73139

SAT depth: 23- 26 m

8.5 Sea Conditions Performance Assessment

* SEE SEPERATE NOISE TEST IN h DOC'S.

During the sea acceptance test, the performance of the whole system shall be assessed. The important factors limiting achievable accuracy and coverage are noise, sea temperature and salinity and sea state. With heavy seas it is to be expected that the performance will also depend upon vessel heading with respect to wave direction. On some vessels the noise level at particular speeds and propeller revolutions may also affect coverage. It is recommended to assess achieved coverage as a function of environmental parameters both during the sea acceptance test and later operation. The results should be entered in the table below, both to document conditions during the test and later to have a record of the system's performance according to external conditions.

The noise experienced by the system may be measured from the Operator Station as described in the Operator Manual. Several measurements should be taken and the result averaged before noting it in the table below:

Date	*Depth (m)*	*Sea State*	*Heading Against Waves*	*Speed*	*RPM*	*Noise*	*Comments*
7/10	23	1		11.3			

The coverage is assessed by observing the swath width on the Operator Station on a reasonably flat bottom. The average of several pings and any occurrence of missed pings should be noted in the table below:

Date	*Depth (m)*	*Sea State*	*Heading Against Waves*	*Speed (kn)*	*RPM*	*Abs. coeff.*	*Coverage (m)* ACROSS	*Missing Pings, Comments*
7/10	23	0-1		11.5		-	115	
	23	"		4			137	
	24	0-1		8.3			77	SET TO 60/60
7/11	24	1-2	↘	8.2	900		99	SET TO 65/65
	23	1-2	↙	0	750		97	
	23	1-2	↗	9	1400		80	
	24	1-2	→	6	750		94	
	24	12	↗	8	1370		100	
	23	1-2	↗	8	1380		101	
	24	1-2	↘	8	1380		99	
	23	1-2	↘	73	1250		100	
	24	1-2	↙	8	1250		97	
	24	1.2	↖	7	1000		97	
	23	1.2	↗	6.5	1000		95	

Performed by (date/sign)	**Witnessed by (date/sign)**
PreSAT: 7/10/2018	*PreSAT:* LTSU/NOAA 7/11/2018
SAT: 7/10/2018	*SAT:* LTSU/NOAA 7/11/2018

9 TESTIMONIAL

The SEA ACCEPTANCE TEST for the EM 2040, for THOMAS JEFFERSON LAUNCH 2904 has been performed according to the test procedure.

This SAT approval is only valid if the test is performed by an engineer certified by Kongsberg Maritime A/S.

The test is: [✓ **Accepted**] / **Not accepted** *(Delete as appropriate)*

Remarks:

① INVESTIGATING NOISE IN STBD SECTOR.
A) SEE TRIP REPORT FOR ADDITIONAL INFO
B) WILL REPORT BACK TO VESSEL AFTER REVIEW OF DATA.
② DEEP WATER NOISE TESTING TO BE PERFORMED DURING LATER TRANSIT. VESSEL TO REPORT BACK ~~RESULTS~~ RESULTS.
③ NOISE LEVELS APPEAR TO BE APROX 5.5-6db NOISIER THAN RAINIER/FAIRWEATHER LAUNCHES.

Please use capital letters:

Test performed by	Position	Company
GREGG JUERGENS	FIELD TECH	Kongsberg Maritime
Test accepted by	**Position**	**Company**
MATTHEW B. SHARR	HSTB - LIAISON	NOAA

Date	Signature
7/11/2018	
7/11/2018	LTJG/NOAA

Kongsberg Underwater Technology, Inc.
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Support: km.support.lynnwood@kongsberg.com
Km.hydrographic.support@kongsberg.com
Support World Wide (Norway) +47 815 35 355

Service Report

CUSTOMER: NOAA	**VESSEL/FACTORY/SITE:** **Thomas Jefferson Launches 2903 & 2904**	**DATE:** 5/17/2018 – 5/24/2018
LOCATION: Pascagoula, MS – Galveston, TX.	**ENGINEER/Technician** Gregg Juergens	**SERIAL/FILE No:** n/a
WORKORDER / PO: **WO01070**	**ACCOUNT/PROJECT No:** n/a	**CONTRACT No:** n/a

EQUIPMENT DELIVERED/INSTALLED/REPLACED.

QTY	Part Desc.	Part No.	Serial No.	Comments.

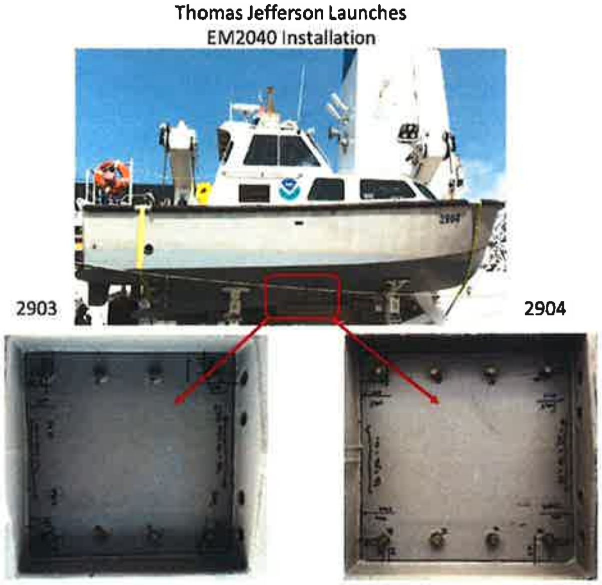
1. Main Purpose of Visit –

- Install EM2040 system on TJ's Launches (2ea)
- Perform HAT on systems
- Perform SAT on systems

2. Overview –

- **5/17/2018** 8Hrs
  - Travel Day, Seattle, WA to Pascagoula, MS

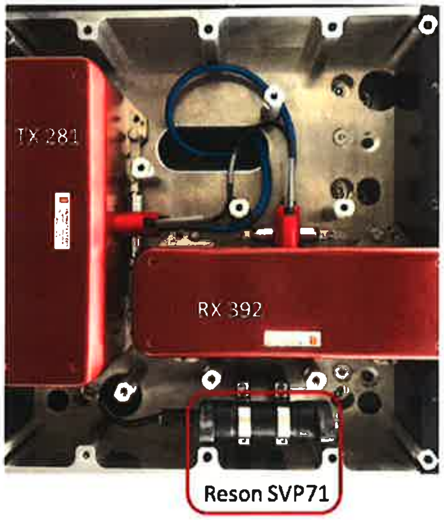
- **5/18/2018** 10Hrs
  - Arrive to vessel 0845
  - Perform cursory inspection of Hull where EM2040 casing will be mounted



  - Discuss plan with crew regarding EM2040 installation
  - Equipment arrived to facility aprox 11:00
    - Divided up equipment per vessel
    - Installed Wheel House equipment into racks on both Launches
      - SIS Work Station
      - EM2040 PU
      - Installed cabling for these pieces

- **5/19/2018** 12Hrs
  - Installed casings and transducers on both Launches

2903



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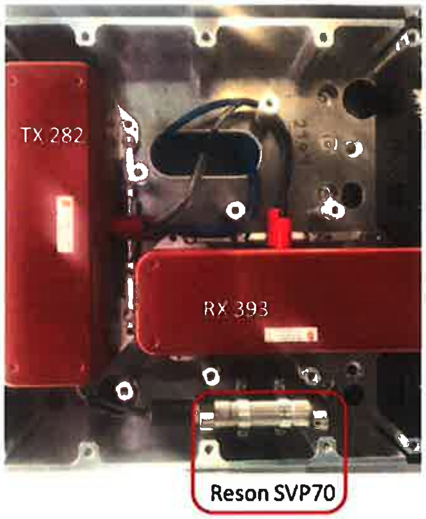

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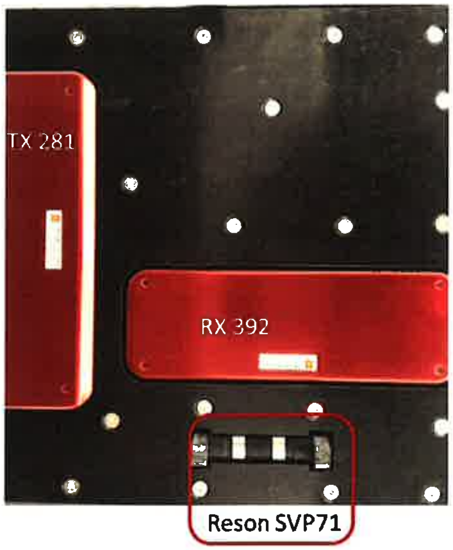

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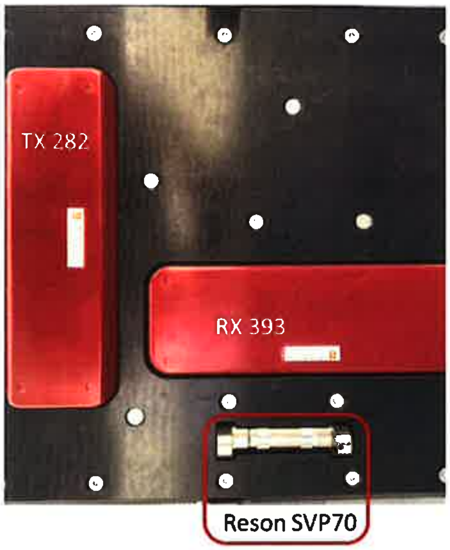

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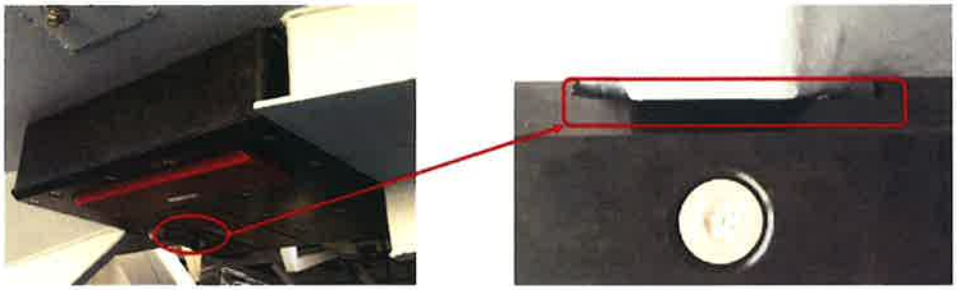
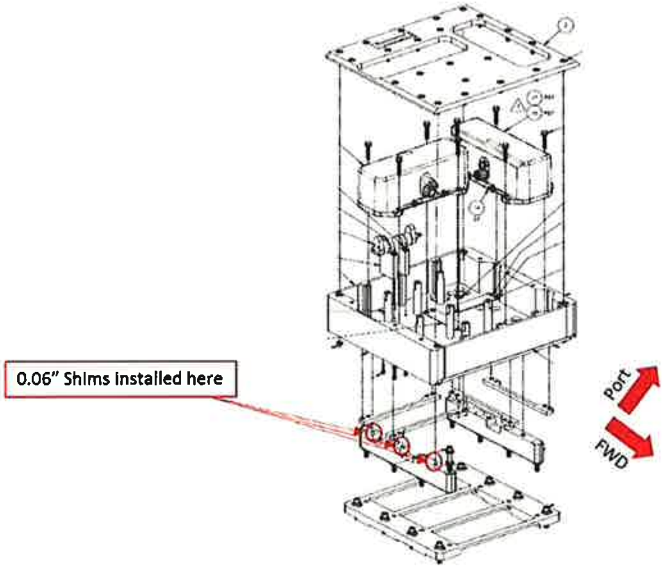
  - On Both Launches modified cover plate to allow for fit



- On Launch 2904 installed 0.06” shims on Starboard support strut to have cover plate sit flush with hull fairing

2904



- **5/20/2018** 12Hrs
  - Finish terminating/connecting system cables inside launches
  - Configure Installation settings for data inputs into PU’s
    - COM1, 19200, 8, 1, None (RS232)
      - GGK and ZDA
    - COM2, 19200, 8, 1, None (RS232)
      - Attitude, EM3000
    - UDP5
      - Attitude Velocity
      - 129.100.1.230 : 5602
    - On Launch 2903 Input Lever arms for RX to TX. All other lever arms applied in POS-MV. POS-MV is outputting valid data at TX Head
      - RX
        - X -0.100
        - Y -0.305
        - Z -0.016

- **5/21/2018** 12Hrs
  - Terminated Reson SVS's on each Launch as follows

Launch 2903

SVP 71 confioguration on Launch **2903**			
6 Pin Connector	Color	Discription	SVS J-Box
1	Black	Com's Gnd	TB5
2	White	TX	TB3
3	Brown	RX	TB4
4	Green	Power 12+	TB1
5	n/a	n/a	n/a
6	Blue	Power Gnd	TB2

Launch 2904

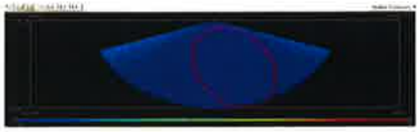
SVP 70 Configuration on aunch **2904**			
9 Pin Connector	Color	Description	SVS J-Box
Shield	Screen	Com's Gnd	TB5
1	n/a	n/a	n/a
2	Black	RX	TB4
3	White	TX	TB3
4	n/a	n/a	n/a
5	n/a	n/a	n/a
6	n/a	n/a	n/a
7	n/a	n/a	n/a
8	Brown	Power Gnd	TB2
9	Orange	Power 12+	TB1

    - Tested both Reson SVS's - all op's appear normal
    - Configured on both Launches - SIS External input to accept on COM1
      - 9600, 8, 1, & none
      - Set Sensor selection to AML SV
  - Performed HAT on Launch 2903 since it was on outside of vessel. 2904 will have to wait until we get out seeing we could not drop into water due to it being pier side
    - HAT results for 2903 all OK
      - Performed BIST – all Pass
        - REF files;
          <HAT_BIST_21May2018.txt>
          <HAT_SystemReport_PU40143_RX392_TX281_20180521_212611>
      - Saved PU Parameter file Post HAT
        - REF file <Post_HAT_Config_21May2018>
  - Departed pier 1630 for initial test site
  - Discovered 2904 full of water in cab, up to floor grating in cab.
    - Further investigation by engineers on board found AC suction hose had come loose. This allowed engine compartment to fill completely flooding Generator, Batteries etc. Due to this 2904 will not be able to be tested during this trial.

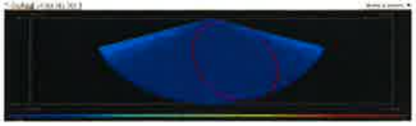
- **5/22/2018** 12Hrs
  - Arrived to test site
  - Vessel deployed Launch aprox 0830
  - Arrived to SAT Cal site
    - Performed Calibration per NOAA requirements using their method
      - Performed Post Cal BIST <SAT_BIST_22May2018 >
    - Performed noise tests at varying speeds etc., see attached file
    - Performed additional noise tests, system put into 'Sonar Passive' Mode and collected varying data at different speeds. This was for NOAA information only.
      - During these tests noted when system set for 200Khz and using Short CW there was noise just to Starboard of Nadir, when selecting another Pulse Mode, IE: Medium, Long or FM the noise either faded or was not present see below->

Short CW 200Khz

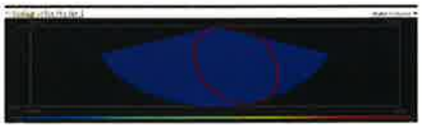
Medium CW 200Khz



Long CW 200Khz



FM 200Khz



        - Performed additional trouble shooting, IE: Power up down other equipment, have vessel go dead in water with the exception of UPS and Generator, no change-
      - Transited back to TJ and was recovered.
        - Will trouble shoot more tomorrow when on Reference Surface site

- **5/23/2018** 12Hrs
  - Vessel arrived to "Reference Surface" site
  - Deployed Launch 2903
  - Ran Ref Surface survey
  - Performed additional trouble shooting on noise seen at 200Khz Short CW
    - Isolated PU
    - Powered down vessel completely so EM2040 only running on Batteries from UPS, noise still present
    - Swapped out PU for one that was installed on Launch 2904, noise still present
    - Further testing showed that noise appears to be affected by-> Pulse Mode selected, Dual Swath on / off, Frq selected – 200, 300 or 400
    - Am leaving system as is for now. Once other launch is operational will compare.
      - Am suggesting to bring an additional RX and TX cable for testing purposes
  -

3. *Software Details –*

- TJ Launch 2903
  - SIS Version 4.32
- TJ Launch 2904
  - SIS Version 4.32

4. *Summary –*

- NOAA Launch 2904
  - Installation of EM2040 completed
  - System has not been tested, No HAT or SAT performed yet due to flooding
  - Vessel to schedule another time after Launch is corrected for us to return to perform HAT and SAT before using for operations.
  - System was powered up prior to flooding to verify operations. At that time all looked OK
    * EM2040 TOPSIDE EQUIPMENT DID NOT GET WET.
- NOAA Launch 2903
  - Installation of EM2040 completed
  - System has been tested, HAT and SAT performed and accepted.
    - Noise on Starboard side is still being looked into. Will revert after discussing with Norway further
    - Will need to compare against Launch 2904 when it is operational
    - Calibrated numbers applied to system
    - Ref Surface performed, discovered 8ms timing error
      - Applied this to system
      - Took PU back up at this time
        - < Post_SAT_Config_23May2018 >
- Provided temporary connections drawing for both Launches

5. *Signatures.*

DATE: 5/23/2018	*KM Represéntitive signature:* *Printed: Gregg Juergens*	*Work Accepted on behalf of Customer signature:* *Printed:* SAMUEL GREENAWAY

Customer NOAA	Vessel/Factory/Site Thomas Jefferson Launches 2903 & 2904	Serial no. n/a
Employee no. JUER001	Service Engineer Gregg Juergens	Page 3 of 3
Location Pascagoula, MS – Galveston, TX	Account no./Job no. WO#01070	Week no.

Day/ date	Off-shore	Description	Time from/to	Norm time	Time diff.
5/17/2018		Travel Day		8	
5/18/2018		Work on vessel pier side		10	
5/19/2018		Work on vessel pier side		12	
5/20/2018	XX	Work on ~~Vessel off shore~~ - PIERSIDE		~~12~~ 10	
5/21/2018	XX	Work on Vessel off shore -		12	
5/22/2018	XX	Work on Vessel off shore -		12	
5/23/2018	XX	Work on Vessel off shore -		12	
5/24/2018	XX	Work on Vessel off shore -		12	
5/25/2018		Travel Day		8	

Date 5/23/2018	Kongsberg representative signature	Work accepted on behalf of customer	Working lime		
		Printed SAMUEL GREENAWAY	Waiting time		
		Signature	Traveling time		

Service provided by: Kongsberg Underwater Technology, Inc.

Service Repair & return Guarantee	On board______ Yes_______ Yes_______	In shop____ No_______ No_______

Kongsberg Underwater Technology, Inc.
19210 33rd Avenue West, Suite A
Lynnwood, WA 98036-4707
425-712-1107 (tel)
425-712-1197 (fax)

Additional Reports

HVF Values

```
Vessel Name: 2903_2019_EchotracCV200.hvf
Vessel created: March 24, 2020


Depth Sensor:

        Sensor Class:   Swath
        Time Stamp:     2019-152 00:00

        Comments:
        Time Correction(s) 0.000

        Transduer #1:
        -------------
        Pitch Offset:   0.000
        Roll Offset:    0.000
        Azimuth Offset:         0.000

        DeltaX:   0.000
        DeltaY:   0.000
        DeltaZ:   0.000

        Manufacturer:
        Model:          oecv
        Serial Number:

        Transducer #2:
        -------------
        Pitch Offset:   0.000
        Roll Offset:    0.000
        Azimuth Offset:         0.000

        DeltaX:   0.000
        DeltaY:   0.000
        DeltaZ:   0.000
```

```
Navigation Sensor:

        Time Stamp:     2019-152 00:00

        Comments: (null)
        Time Correction(s) 0.000
        DeltaX:   0.000
        DeltaY:   0.000
        DeltaZ:   0.000

        Manufacturer:   (null)
        Model:          (null)
        Serial Number:          (null)
```

```
Gyro Sensor:
```

Time Stamp: 2019-152 00:00

Comments: (null)
Time Correction(s) 0.000

Heave Sensor:

Time Stamp: 2019-152 00:00

Comments: (null)
Apply No
Time Correction(s) 0.000
DeltaX: 0.000
DeltaY: 0.000
DeltaZ: 0.000
Offset: 0.000

Manufacturer: (null)
Model: (null)
Serial Number: (null)

Pitch Sensor:

Time Stamp: 2019-152 00:00

Comments: (null)
Apply No
Time Correction(s) 0.000
Pitch offset: 0.000

Manufacturer: (null)
Model: (null)
Serial Number: (null)

Roll Sensor:

Time Stamp: 2019-152 00:00

Comments: (null)
Apply No
Time Correction(s) 0.000
Roll offset: 0.000

Manufacturer: (null)
Model: (null)
Serial Number: (null)

Draft Sensor:

Time Stamp: 2019-152 00:00

Apply Yes
Comments: (null)
Time Correction(s) 0.000

Entry 1) Draft: 0.000 Speed: 0.000
Entry 2) Draft: -0.007 Speed: 0.972
Entry 3) Draft: -0.003 Speed: 1.944
Entry 4) Draft: 0.013 Speed: 2.916
Entry 5) Draft: 0.030 Speed: 3.888
Entry 6) Draft: 0.050 Speed: 4.860
Entry 7) Draft: 0.063 Speed: 5.832
Entry 8) Draft: 0.067 Speed: 6.803
Entry 9) Draft: 0.060 Speed: 7.775
Entry 10) Draft: 0.043 Speed: 8.747
Entry 11) Draft: 0.007 Speed: 9.719
Entry 12) Draft: -0.053 Speed: 10.691
Entry 13) Draft: -0.133 Speed: 11.663

TPU

Time Stamp: 2019-152 00:00

Comments:
Offsets

Motion sensing unit to the transducer 1
  X Head 1 0.205
  Y Head 1 0.152
  Z Head 1 0.536
Motion sensing unit to the transducer 2
  X Head 2 -0.100
  Y Head 2 0.052
  Z Head 2 0.520
Navigation antenna to the transducer 1
  X Head 1 0.922
  Y Head 1 0.896
  Z Head 1 4.185
Navigation antenna to the transducer 2
  X Head 2 0.617
  Y Head 2 0.796
  Z Head 2 4.169

Roll offset of transducer number 1 -0.965
Roll offset of transducer number 2 0.000

Heave Error: 0.050 or 5.000" of heave amplitude.
Measurement errors: 0.020
Motion sensing unit alignment errors
Gyro:0.040 Pitch:0.120 Roll:0.120
Gyro measurement error: 0.020
Roll measurement error: 0.020
Pitch measurement error: 0.020

```
    Navigation measurement error: 0.500
    Transducer timing error: 0.001
    Navigation timing error: 0.001
    Gyro timing error: 0.001
    Heave timing error: 0.001
    PitchTimingStdDev: 0.001
    Roll timing error: 0.001
    Sound Velocity speed measurement error: 0.000
    Surface sound speed measurement error: 0.000
    Tide measurement error: 0.000
    Tide zoning error: 0.000
    Speed over ground measurement error: 0.500
    Dynamic loading measurement error: 0.030
    Static draft measurement error: 0.030
    Delta draft measurement error: 0.020
    StDev Comment: (null)
________________________________________________________________
Svp Sensor:

    Time Stamp:    2019152:0000

    Comments:
    Time Correction(s) 0.000

    Svp #1:
    -------------
    Pitch Offset:    0.000
    Roll Offset:     0.000
    Azimuth Offset:      0.000

    DeltaX:   0.000
    DeltaY:   0.000
    DeltaZ:   -0.490

    SVP #2:
    -------------
    Pitch Offset:    0.000
    Roll Offset:     0.000
    Azimuth Offset:      0.000

    DeltaX:   0.000
    DeltaY:   0.000
    DeltaZ:   0.000


    Time Stamp:    2019189:1130

    Comments:
    Time Correction(s) 0.000

    Svp #1:
    -------------
    Pitch Offset:    0.000
    Roll Offset:     0.000
```

```
Azimuth Offset:     0.000

DeltaX:   0.000
DeltaY:   0.000
DeltaZ:   0.000

SVP #2:
-------------
Pitch Offset:   0.000
Roll Offset:    0.000
Azimuth Offset:     0.000

DeltaX:   0.000
DeltaY:   0.000
DeltaZ:   0.000


Time Stamp:    2019189:1415

Comments:
Time Correction(s) 0.000

Svp #1:
-------------
Pitch Offset:   0.000
Roll Offset:    0.000
Azimuth Offset:     0.000

DeltaX:   0.000
DeltaY:   0.000
DeltaZ:   -0.490

SVP #2:
-------------
Pitch Offset:   0.000
Roll Offset:    0.000
Azimuth Offset:     0.000

DeltaX:   0.000
DeltaY:   0.000
DeltaZ:   0.000


Time Stamp:    2019210:0000

Comments:
Time Correction(s) 0.000

Svp #1:
-------------
Pitch Offset:   0.000
Roll Offset:    0.000
Azimuth Offset:     0.000
```

```
     DeltaX:   0.000
     DeltaY:   0.000
     DeltaZ:   0.000

     SVP #2:
     -------------
     Pitch Offset:   0.000
     Roll Offset:    0.000
     Azimuth Offset:      0.000

     DeltaX:   0.000
     DeltaY:   0.000
     DeltaZ:   0.000

WaterLine:

     Time Stamp:   2019-152 00:00

     Comments:
     Apply No
     WaterLine -0.624

     Time Stamp:   2019-157 00:00

     Comments:
     Apply No
     WaterLine -0.615
```

Vessel Name: 2903_2019_Edgetech4200MP_100.hvf
Vessel created: March 24, 2020

Navigation Sensor:

Time Stamp: 2019-183 00:00

Comments: (null)
Time Correction(s) 0.000
DeltaX: 0.000
DeltaY: 0.000
DeltaZ: 0.000

Manufacturer: Applanix
Model: POS M/V V5
Serial Number: (null)

Gyro Sensor:

Time Stamp: 2019-183 00:00

Comments: (null)
Time Correction(s) 0.000

Tow Point:

Time Stamp: 2019-183 00:00

Comments:
Time Correction(s) 0.000
DeltaX: 0.564
DeltaY: 0.654
DeltaZ: 0.310

Manufacturer:
Model:
Serial Number:

Vessel Name: 2903_2019_Edgetech4200MP_200.hvf
Vessel created: March 24, 2020

Navigation Sensor:

Time Stamp: 2019-183 00:00

Comments: (null)
Time Correction(s) 0.000
DeltaX: 0.000
DeltaY: 0.000
DeltaZ: 0.000

Manufacturer: Applanix
Model: POS M/V V4
Serial Number: (null)

Gyro Sensor:

Time Stamp: 2019-183 00:00

Comments: (null)
Time Correction(s) 0.000

Tow Point:

Time Stamp: 2019-183 00:00

Comments:
Time Correction(s) 0.000
DeltaX: 0.564
DeltaY: 0.654
DeltaZ: 0.310

Manufacturer:
Model:
Serial Number:

Vessel Name: 2903_2019_Klein_100_2019.hvf
Vessel created: March 24, 2020

Navigation Sensor:

Time Stamp: 2019-205 00:00

Comments: (null)
Time Correction(s) 0.000
DeltaX: 0.000
DeltaY: 0.000
DeltaZ: 0.000

Manufacturer: Applanix
Model: POS M/V V5
Serial Number: (null)

Gyro Sensor:

Time Stamp: 2019-205 00:00

Comments: (null)
Time Correction(s) 0.000

Tow Point:

Time Stamp: 2019-205 00:00

Comments:
Time Correction(s) 0.000
DeltaX: 0.564
DeltaY: 0.654
DeltaZ: 0.310

Manufacturer:
Model:
Serial Number:

Vessel Name: 2903_2019_Klein_200_2019.hvf
Vessel created: March 24, 2020

Navigation Sensor:

Time Stamp: 2019-205 00:00

Comments: (null)
Time Correction(s) 0.000
DeltaX: 0.000
DeltaY: 0.000
DeltaZ: 0.000

Manufacturer: Applanix
Model: POS M/V V4
Serial Number: (null)

Gyro Sensor:

Time Stamp: 2019-205 00:00

Comments: (null)
Time Correction(s) 0.000

Tow Point:

Time Stamp: 2019-205 00:00

Comments:
Time Correction(s) 0.000
DeltaX: 0.564
DeltaY: 0.654
DeltaZ: 0.310

Manufacturer:
Model:
Serial Number:

Vessel Name: 2903_2019_KongsbergEM2040.hvf
Vessel created: April 29, 2020

Depth Sensor:

Sensor Class: Swath
Time Stamp: 2019-157 00:00

Comments:
Time Correction(s) 0.000

Transduer #1:

Pitch Offset: 0.000
Roll Offset: 0.000
Azimuth Offset: 0.000

DeltaX: 0.000
DeltaY: 0.000
DeltaZ: 0.000

Manufacturer:
Model: em2040_300N
Serial Number:

Transducer #2:

Pitch Offset: 0.000
Roll Offset: 0.000
Azimuth Offset: 0.000

DeltaX: 0.000
DeltaY: 0.000
DeltaZ: 0.000

Navigation Sensor:

Time Stamp: 2019-157 00:00

Comments: (null)
Time Correction(s) 0.000
DeltaX: 0.000
DeltaY: 0.000
DeltaZ: 0.000

Manufacturer: (null)
Model: (null)
Serial Number: (null)

Gyro Sensor:

Time Stamp: 2019-157 00:00

Comments: (null)
Time Correction(s) 0.000

Heave Sensor:

Time Stamp: 2019-157 00:00

Comments: (null)
Apply No
Time Correction(s) 0.000
DeltaX: 0.000
DeltaY: 0.000
DeltaZ: 0.000
Offset: 0.000

Manufacturer: (null)
Model: (null)
Serial Number: (null)

Pitch Sensor:

Time Stamp: 2019-157 00:00

Comments: (null)
Apply No
Time Correction(s) 0.000
Pitch offset: 0.000

Manufacturer: (null)
Model: (null)
Serial Number: (null)

Roll Sensor:

Time Stamp: 2019-157 00:00

Comments: (null)
Apply No
Time Correction(s) 0.000
Roll offset: 0.000

Manufacturer: (null)
Model: (null)
Serial Number: (null)

Draft Sensor:

Time Stamp: 2019-152 00:00

Apply Yes
Comments: (null)
Time Correction(s) 0.000

Entry 1) Draft: 0.000 Speed: 0.000
Entry 2) Draft: -0.007 Speed: 0.972
Entry 3) Draft: -0.003 Speed: 1.944
Entry 4) Draft: 0.013 Speed: 2.916
Entry 5) Draft: 0.030 Speed: 3.888
Entry 6) Draft: 0.050 Speed: 4.860
Entry 7) Draft: 0.063 Speed: 5.832
Entry 8) Draft: 0.067 Speed: 6.803
Entry 9) Draft: 0.060 Speed: 7.775
Entry 10) Draft: 0.043 Speed: 8.747
Entry 11) Draft: 0.007 Speed: 9.719
Entry 12) Draft: -0.053 Speed: 10.691
Entry 13) Draft: -0.133 Speed: 11.663

TPU

Time Stamp: 2019-269 00:00

Comments:
Offsets

Motion sensing unit to the transducer 1
X Head 1 0.177
Y Head 1 0.141
Z Head 1 0.577
Motion sensing unit to the transducer 2
X Head 2 -0.128
Y Head 2 0.041
Z Head 2 0.561
Navigation antenna to the transducer 1
X Head 1 0.922
Y Head 1 0.896
Z Head 1 4.185
Navigation antenna to the transducer 2
X Head 2 0.617
Y Head 2 0.796
Z Head 2 4.169

Roll offset of transducer number 1 -0.021
Roll offset of transducer number 2 0.000

Heave Error: 0.050 or 5.000" of heave amplitude.
Measurement errors: 0.020
Motion sensing unit alignment errors
Gyro:0.090 Pitch:0.160 Roll:0.160
Gyro measurement error: 0.020
Roll measurement error: 0.020
Pitch measurement error: 0.020

Navigation measurement error: 0.500
Transducer timing error: 0.001
Navigation timing error: 0.001
Gyro timing error: 0.001
Heave timing error: 0.001
PitchTimingStdDev: 0.001
Roll timing error: 0.001
Sound Velocity speed measurement error: 0.000
Surface sound speed measurement error: 0.000
Tide measurement error: 0.000
Tide zoning error: 0.000
Speed over ground measurement error: 0.500
Dynamic loading measurement error: 0.030
Static draft measurement error: 0.030
Delta draft measurement error: 0.020
StDev Comment: (null)

Time Stamp: 2019-316 00:00

Comments:
Offsets

Motion sensing unit to the transducer 1
    X Head 1 0.205
    Y Head 1 0.152
    Z Head 1 0.536
Motion sensing unit to the transducer 2
    X Head 2 -0.100
    Y Head 2 0.052
    Z Head 2 0.520
Navigation antenna to the transducer 1
    X Head 1 0.922
    Y Head 1 0.896
    Z Head 1 4.185
Navigation antenna to the transducer 2
    X Head 2 0.617
    Y Head 2 0.796
    Z Head 2 4.169

Roll offset of transducer number 1 -0.965
Roll offset of transducer number 2 0.000

Heave Error: 0.050 or 5.000" of heave amplitude.
Measurement errors: 0.020
Motion sensing unit alignment errors
Gyro:0.040 Pitch:0.120 Roll:0.120
Gyro measurement error: 0.020
Roll measurement error: 0.020
Pitch measurement error: 0.020
Navigation measurement error: 0.500
Transducer timing error: 0.001
Navigation timing error: 0.001
Gyro timing error: 0.001
Heave timing error: 0.001

```
    PitchTimingStdDev: 0.001
    Roll timing error: 0.001
    Sound Velocity speed measurement error: 0.000
    Surface sound speed measurement error: 0.000
    Tide measurement error: 0.000
    Tide zoning error: 0.000
    Speed over ground measurement error: 0.500
    Dynamic loading measurement error: 0.030
    Static draft measurement error: 0.030
    Delta draft measurement error: 0.020
    StDev Comment: (null)
```

```
Svp Sensor:

    Time Stamp:    2019157:0000

    Comments:
    Time Correction(s) 0.000

    Svp #1:
    -------------
    Pitch Offset:    0.000
    Roll Offset:     0.000
    Azimuth Offset:      0.000

    DeltaX:   0.000
    DeltaY:   0.000
    DeltaZ:   0.000

    SVP #2:
    -------------
    Pitch Offset:    0.000
    Roll Offset:     0.000
    Azimuth Offset:      0.000

    DeltaX:   -0.305
    DeltaY:   -0.100
    DeltaZ:   -0.016


    Time Stamp:    2019297:0000

    Comments:
    Time Correction(s) 0.000

    Svp #1:
    -------------
    Pitch Offset:    0.000
    Roll Offset:     0.000
    Azimuth Offset:      0.000

    DeltaX:   0.000
    DeltaY:   0.000
    DeltaZ:   0.000
```

SVP #2:

Pitch Offset: 0.000
Roll Offset: -0.100
Azimuth Offset: 0.000

DeltaX: -0.305
DeltaY: -0.100
DeltaZ: -0.016

Time Stamp: 2019298:0000

Comments:
Time Correction(s) 0.000

Svp #1:

Pitch Offset: 0.000
Roll Offset: 0.000
Azimuth Offset: 0.000

DeltaX: 0.000
DeltaY: 0.000
DeltaZ: 0.000

SVP #2:

Pitch Offset: 0.000
Roll Offset: 0.000
Azimuth Offset: 0.000

DeltaX: -0.305
DeltaY: -0.100
DeltaZ: -0.016

WaterLine:

Time Stamp: 2019-157 00:00

Comments:
Apply No
WaterLine -0.615

Vessel Name: 2904_2019_Edgetech4200MP_100.hvf
Vessel created: March 24, 2020

Navigation Sensor:

Time Stamp: 2019-184 00:00

Comments: (null)
Time Correction(s) 0.000
DeltaX: 0.000
DeltaY: 0.000
DeltaZ: 0.000

Manufacturer: Applanix
Model: POS M/V V5
Serial Number: (null)

Gyro Sensor:

Time Stamp: 2019-184 00:00

Comments: (null)
Time Correction(s) 0.000

Tow Point:

Time Stamp: 2019-184 00:00

Comments:
Time Correction(s) 0.000
DeltaX: 0.574
DeltaY: 0.659
DeltaZ: 0.306

Manufacturer:
Model:
Serial Number:

Vessel Name: 2904_2019_Edgetech4200MP_200.hvf
Vessel created: March 24, 2020

Navigation Sensor:

Time Stamp: 2019-184 00:00

Comments: (null)
Time Correction(s) 0.000
DeltaX: 0.000
DeltaY: 0.000
DeltaZ: 0.000

Manufacturer: Applanix
Model: POS M/V V4
Serial Number: (null)

Gyro Sensor:

Time Stamp: 2019-184 00:00

Comments: (null)
Time Correction(s) 0.000

Tow Point:

Time Stamp: 2019-184 00:00

Comments:
Time Correction(s) 0.000
DeltaX: 0.574
DeltaY: 0.659
DeltaZ: 0.306

Manufacturer:
Model:
Serial Number:

```
Vessel Name: 2904_2019_KongsbergEM2040.hvf
Vessel created: March 24, 2020


Depth Sensor:

    Sensor Class:   Swath
    Time Stamp:     2019-157 00:00

    Comments:
    Time Correction(s) 0.000

    Transduer #1:
    -------------
    Pitch Offset:   0.000
    Roll Offset:    0.000
    Azimuth Offset:     0.000

    DeltaX:   0.000
    DeltaY:   0.000
    DeltaZ:   0.000

    Manufacturer:
    Model:          em2040_300N
    Serial Number:

    Transducer #2:
    -------------
    Pitch Offset:   0.000
    Roll Offset:    0.000
    Azimuth Offset:     0.000

    DeltaX:   0.000
    DeltaY:   0.000
    DeltaZ:   0.000

_______________________________________________________
Navigation Sensor:

    Time Stamp:     2019-157 00:00

    Comments: (null)
    Time Correction(s) 0.000
    DeltaX:   0.000
    DeltaY:   0.000
    DeltaZ:   0.000

    Manufacturer:  (null)
    Model:         (null)
    Serial Number:       (null)

_______________________________________________________
Gyro Sensor:
```

Time Stamp: 2019-157 00:00

Comments: (null)
Time Correction(s) 0.000

Heave Sensor:

Time Stamp: 2019-157 00:00

Comments: (null)
Apply No
Time Correction(s) 0.000
DeltaX: 0.000
DeltaY: 0.000
DeltaZ: 0.000
Offset: 0.000

Manufacturer: (null)
Model: (null)
Serial Number: (null)

Pitch Sensor:

Time Stamp: 2019-157 00:00

Comments: (null)
Apply No
Time Correction(s) 0.000
Pitch offset: 0.000

Manufacturer: (null)
Model: (null)
Serial Number: (null)

Roll Sensor:

Time Stamp: 2019-157 00:00

Comments: (null)
Apply No
Time Correction(s) 0.000
Roll offset: 0.000

Manufacturer: (null)
Model: (null)
Serial Number: (null)

Draft Sensor:

Time Stamp: 2019-154 00:00

Apply Yes
Comments:
Time Correction(s) 0.000

Entry 1) Draft: 0.000 Speed: 0.000
Entry 2) Draft: -0.040 Speed: 0.972
Entry 3) Draft: -0.050 Speed: 1.944
Entry 4) Draft: -0.040 Speed: 2.916
Entry 5) Draft: -0.020 Speed: 3.888
Entry 6) Draft: 0.010 Speed: 4.860
Entry 7) Draft: 0.040 Speed: 5.832
Entry 8) Draft: 0.080 Speed: 6.803
Entry 9) Draft: 0.105 Speed: 7.775
Entry 10) Draft: 0.100 Speed: 8.747
Entry 11) Draft: 0.070 Speed: 9.719
Entry 12) Draft: 0.015 Speed: 10.691
Entry 13) Draft: -0.060 Speed: 11.663
Entry 14) Draft: -0.135 Speed: 12.635
Entry 15) Draft: -0.210 Speed: 13.607

Time Stamp: 2019-188 00:00

Apply Yes
Comments:
Time Correction(s) 0.000

Entry 1) Draft: 0.000 Speed: 0.000
Entry 2) Draft: -0.017 Speed: 0.972
Entry 3) Draft: -0.013 Speed: 1.944
Entry 4) Draft: 0.000 Speed: 2.916
Entry 5) Draft: 0.020 Speed: 3.888
Entry 6) Draft: 0.040 Speed: 4.860
Entry 7) Draft: 0.053 Speed: 5.832
Entry 8) Draft: 0.060 Speed: 6.803
Entry 9) Draft: 0.057 Speed: 7.775
Entry 10) Draft: 0.040 Speed: 8.747
Entry 11) Draft: 0.013 Speed: 9.719
Entry 12) Draft: -0.023 Speed: 10.691
Entry 13) Draft: -0.073 Speed: 11.663
Entry 14) Draft: -0.120 Speed: 12.635
Entry 15) Draft: -0.167 Speed: 13.607

TPU

Time Stamp: 2019-189 00:00

Comments:
Offsets

Motion sensing unit to the transducer 1
X Head 1 0.165
Y Head 1 0.143

Z Head 1 0.579
Motion sensing unit to the transducer 2
X Head 2 -0.115
Y Head 2 0.057
Z Head 2 0.522
Navigation antenna to the transducer 1
X Head 1 0.923
Y Head 1 0.889
Z Head 1 4.193
Navigation antenna to the transducer 2
X Head 2 0.618
Y Head 2 0.789
Z Head 2 4.177

Roll offset of transducer number 1 -0.050
Roll offset of transducer number 2 0.000

Heave Error: 0.050 or 5.000" of heave amplitude.
Measurement errors: 0.020
Motion sensing unit alignment errors
Gyro:0.390 Pitch:0.040 Roll:0.040
Gyro measurement error: 0.020
Roll measurement error: 0.020
Pitch measurement error: 0.020
Navigation measurement error: 0.500
Transducer timing error: 0.001
Navigation timing error: 0.001
Gyro timing error: 0.001
Heave timing error: 0.001
PitchTimingStdDev: 0.001
Roll timing error: 0.001
Sound Velocity speed measurement error: 0.000
Surface sound speed measurement error: 0.000
Tide measurement error: 0.000
Tide zoning error: 0.000
Speed over ground measurement error: 0.500
Dynamic loading measurement error: 0.030
Static draft measurement error: 0.030
Delta draft measurement error: 0.030
StDev Comment: (null)

Time Stamp: 2019-339 00:00

Comments:
Offsets

Motion sensing unit to the transducer 1
X Head 1 0.165
Y Head 1 0.144
Z Head 1 0.579
Motion sensing unit to the transducer 2
X Head 2 -0.140
Y Head 2 0.044
Z Head 2 0.563

Navigation antenna to the transducer 1
    X Head 1 0.923
    Y Head 1 0.889
    Z Head 1 4.193
Navigation antenna to the transducer 2
    X Head 2 0.618
    Y Head 2 0.789
    Z Head 2 4.177

Roll offset of transducer number 1 0.000
Roll offset of transducer number 2 0.000

Heave Error: 0.050 or 5.000" of heave amplitude.
Measurement errors: 0.020
Motion sensing unit alignment errors
Gyro:0.220 Pitch:0.260 Roll:0.260
Gyro measurement error: 0.020
Roll measurement error: 0.020
Pitch measurement error: 0.020
Navigation measurement error: 0.500
Transducer timing error: 0.001
Navigation timing error: 0.001
Gyro timing error: 0.001
Heave timing error: 0.001
PitchTimingStdDev: 0.001
Roll timing error: 0.001
Sound Velocity speed measurement error: 0.000
Surface sound speed measurement error: 0.000
Tide measurement error: 0.000
Tide zoning error: 0.000
Speed over ground measurement error: 0.500
Dynamic loading measurement error: 0.030
Static draft measurement error: 0.030
Delta draft measurement error: 0.030
StDev Comment: (null)

Time Stamp: 2019-352 00:00

Comments:
Offsets

Motion sensing unit to the transducer 1
    X Head 1 0.165
    Y Head 1 0.144
    Z Head 1 0.579
Motion sensing unit to the transducer 2
    X Head 2 -0.140
    Y Head 2 0.044
    Z Head 2 0.563
Navigation antenna to the transducer 1
    X Head 1 0.923
    Y Head 1 0.889
    Z Head 1 4.193
Navigation antenna to the transducer 2

X Head 2 0.618
Y Head 2 0.789
Z Head 2 4.177

Roll offset of transducer number 1 0.000
Roll offset of transducer number 2 0.000

Heave Error: 0.050 or 5.000" of heave amplitude.
Measurement errors: 0.020
Motion sensing unit alignment errors
Gyro:0.140 Pitch:0.120 Roll:0.120
Gyro measurement error: 0.020
Roll measurement error: 0.020
Pitch measurement error: 0.020
Navigation measurement error: 0.500
Transducer timing error: 0.001
Navigation timing error: 0.001
Gyro timing error: 0.001
Heave timing error: 0.001
PitchTimingStdDev: 0.001
Roll timing error: 0.001
Sound Velocity speed measurement error: 0.000
Surface sound speed measurement error: 0.000
Tide measurement error: 0.000
Tide zoning error: 0.000
Speed over ground measurement error: 0.500
Dynamic loading measurement error: 0.030
Static draft measurement error: 0.030
Delta draft measurement error: 0.030
StDev Comment: (null)

Svp Sensor:

Time Stamp: 2019157:0000

Comments:
Time Correction(s) 0.000

Svp #1:

Pitch Offset: 0.000
Roll Offset: 0.000
Azimuth Offset: 0.000

DeltaX: 0.000
DeltaY: 0.000
DeltaZ: 0.000

SVP #2:

Pitch Offset: 0.000
Roll Offset: 0.270
Azimuth Offset: 0.000

```
DeltaX:   -0.305
DeltaY:   -0.100
DeltaZ:   -0.016


Time Stamp:    2019196:0000

Comments:
Time Correction(s) 0.000

Svp #1:
-------------
Pitch Offset:   0.000
Roll Offset:    0.000
Azimuth Offset:      0.000

DeltaX:   0.000
DeltaY:   0.000
DeltaZ:   0.000

SVP #2:
-------------
Pitch Offset:   0.000
Roll Offset:    0.110
Azimuth Offset:      0.000

DeltaX:   -0.305
DeltaY:   -0.100
DeltaZ:   -0.016


Time Stamp:    2019197:0000

Comments:
Time Correction(s) 0.000

Svp #1:
-------------
Pitch Offset:   0.000
Roll Offset:    0.000
Azimuth Offset:      0.000

DeltaX:   0.000
DeltaY:   0.000
DeltaZ:   0.000

SVP #2:
-------------
Pitch Offset:   0.000
Roll Offset:    0.000
Azimuth Offset:      0.000

DeltaX:   -0.305
DeltaY:   -0.100
```

```
DeltaZ:    -0.016


Time Stamp:    2019339:0000

Comments:
Time Correction(s) 0.000

Svp #1:
-------------
Pitch Offset:    0.860
Roll Offset:     0.200
Azimuth Offset:      4.360

DeltaX:    0.000
DeltaY:    0.000
DeltaZ:    0.000

SVP #2:
-------------
Pitch Offset:    0.000
Roll Offset:     0.000
Azimuth Offset:      0.000

DeltaX:    -0.305
DeltaY:    -0.100
DeltaZ:    -0.016


Time Stamp:    2019352:0000

Comments:
Time Correction(s) 0.000

Svp #1:
-------------
Pitch Offset:    -0.610
Roll Offset:     0.630
Azimuth Offset:      1.620

DeltaX:    0.000
DeltaY:    0.000
DeltaZ:    0.000

SVP #2:
-------------
Pitch Offset:    0.000
Roll Offset:     0.000
Azimuth Offset:      0.000

DeltaX:    -0.305
DeltaY:    -0.100
DeltaZ:    -0.016
```

WaterLine:

Time Stamp: 2019-157 00:00

Comments:
Apply No
WaterLine -0.694

Time Stamp: 2019-197 00:00

Comments:
Apply No
WaterLine -0.618

HSRR Documentation

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Office of Marine and Aviation Operations,
Marine Operation Center-Atlantic, NOAA Ship *Thomas Jefferson*
Norfolk, Virginia 23510

November 22, 2019

MEMORANDUM FOR: Captain Richard T. Brennan, NOAA
Chief, Hydrographic Surveys Division

FROM: Commander Briana W. Hillstrom, NOAA
Commanding Officer, NOAA Ship *Thomas Jefferson*

SUBJECT: NOAA Ship *Thomas Jefferson* Hydrographic Systems Status Summary

The hydrographic systems of NOAA Ship *Thomas Jefferson* were reviewed in accordance with the Office of Coast Survey Field Procedures Manual (FPM) Hydrographic Systems Readiness Review procedures. *Thomas Jefferson* ran system certification operations in the lower Chesapeake Bay and Elizabeth River in May and June 2019. HSRR system certification operations were completed in the approaches to Chesapeake, lower Chesapeake Bay, and Elizabeth River in November 2019. With NOAA Ship *Thomas Jefferson* in dry dock, Hydrographic Systems Readiness Review for Hydrographic survey launch 2903 and 2904 was completed on 10 June 2019, while *Thomas Jefferson* Hydrographic Systems Readiness Review was completed 11 November 2019. Hydrographic Systems Readiness Review for Hydrographic survey launch 2903, in respect to its multibeam system, was completed 12 November 2019.

All certification tests were conducted and reviewed by a Hydrographic Systems Review Team comprised of the following people:

LT Charles Wisotzkey, Operations Officer
Joshua Hiteshew, Chief Hydrographic Survey Technician
Thomas Jefferson Survey Department
Thomas Jefferson Junior Officers

The team installed and tested all systems except as noted below. The appropriate calibrations, checks, and tests have been performed, and all tested satisfactorily except as noted below.

The Review Team's findings are summarized in this memorandum and reflect the condition of *Thomas Jefferson*'s hydrographic systems on the review date. These findings have been divided into three categories of deficiencies:

CATEGORY 1 – These deficiencies indicate the failure or absence of vital equipment or preparations of systems essential to acquisition and/or processing of hydrographic data. The vessel will be required to cease or limit hydrographic survey operations due to the following deficiencies:

1. *Kongsberg EM 710 MBES:* The ship's EM710 mid-water multibeam echosounder (MBES) failed the BIST test shortly after the ship was refloated from drydock and returned to service in September 2019. The failure has been reported to OMAO in the form of a casualty report and a Kongberg tech assist is pending for December 2019. The planned project areas for the remainder of CY2019 do not require a mid-water MBES.

CATEGORY 2 – These deficiencies indicate noncompliance with established policies, directives, instructions, or accepted hydrographic practice not addressed under Category 1. The following deficiencies shall be corrected in as timely a manner as funding, time, and/or professional assistance permit:

1. *Micro Bubble Artifact in EM2040/EM710:* The ship's "duckbill" was removed from the ship during the 2019 drydock in an attempt to eliminate the micro-bubble artifact reported in previous years' HSRR memos. A limited test of the EM2040 ("star pattern" run in seas) appears to show that the micro-bubble artifact has been reduced or resolved. However, additional testing of both the EM2040 and EM710 is required, and until then, the ship may continue to use reduced swath widths of up to 90^o.
2. *Moving Vessel Profiler (MVP)*: The ship's MVP is showing signs of age. At present, the MVP functions adequately, but is no longer supported by the manufacturer and has fairly significant external corrosion. Additionally, its cable is down to 150 meters, of which 110 meters is usable. An MVP tech assist has been scheduled by the ship's Mission Rep for potential future overhaul.
3. *Side Scan Sonar Winch:* The ship's Side Scan Sonar winch is well past its useful life. Parts are becoming more scarce as time goes on, and preservation of it against the corrosion that has already set in will be a major undertaking by deck department. Its replacement is requested as soon as funds are available

CATEGORY 3 – These deficiencies are associated with observations during the course of the review which merit consideration for corrective actions. These observations are included for review and dialogue related to potential problem areas and hydrographic operational efficiency. It is important to assure that resources (funds, skills, and time) are available at the operating level in order to meet the needs identified in this report and to sustain the efficient operation, upkeep, and repair of the field unit's hydrographic systems.

1. Survey department and wardroom experience is limited. The CST, FOO, and one ST, are the only personnel aboard who have surveyed aboard the ship in preivous field seasons. Special attention should be paid to training and qualifccation opportunities for *Thomas Jefferson* survey personnel both aboard and ashore.
2. Launch wiring diagrams have not been unpdated to reflect the installation and integration of the Kongsberg EM2040s that occurred in 2018; nor have the new

sonars been surveyed into the new launch offset/benchmarking systems. Crew will persue an new launch survey from NGS during the winter of 2020.
3. Boat books do not exist and would pontenially contribute to more seamless survey operations in a high-turnover staffing environment.
4. During the course of 2019, one of *Thomas Jefferson's* launch EM2040 Recivers was loaned to NOAA Ship *Rainier*, disrupting the ship's operations and limiting the launch to singlebeam and side scan operations only. Procurement of a fleet spare EM2040 is highly recommended to limit the fleet's vulnerabity to reduced operational capacity.

The following is a list of calibrations for each platform associated with *Thomas Jefferson*. Calibrations not completed appear in red italics.

Thomas Jefferson (S-222):
- CTD calibration
- Surface Sound Velocity calibration (includes SV&P's used for MVP system)
- CTD Comparison – includes probe mounted in MVP, and all CTD's aboard.
- GAMS calibration
- Ellipsoidally Referenced Dynamic Draft
- Multibeam Patch Test: EM2040 *and EM710*
- *Multibeam vs leadline comparison*
- Reference Surface
- Side Scan Sonar Certification: *50/75*/100 meters

HSL 2903:
- CTD Comparison
- GAMS calibration
- Ellipsoidally Referenced Dynamic Draft
- Vertical beam Patch Test: 128 kHz
- Multibeam Patch Test: 300 kHz
- *Multibeam vs. leadline comparison*
- Reference Surface: 300/128 kHz
- Multibeam vs Vertical beam *vs leadline comparison*
- Side Scan Sonar Calibration: *25*/*50*/75/100 meters

HSL 2904:
- CTD Comparison
- GAMS calibration
- Ellipsoidally Referenced Dynamic Draft
- Multibeam Patch Test: 300 kHz
- Multibeam vs. leadline comparison
- Reference Surface: 300 kHz
- Multibeam vs Vertical beam vs *leadline comparison*
- Side Scan Sonar Calibration: 50/75/*100* meters

THOMAS JEFFERSON

Multibeam Echosounder Calibration Vessel: 2904 EM2040

Date Acquired: 07/15/2019

Processing Log

Date	Dn	Personnel
7/15/2019	196	CHST Hiteshew

☑ **Data converted --> HDCS_Data in CARIS**

☑ **Delayed Heave applied**

☑ **SVP applied**

☑ **SBET applied**

☑ **GPS Tide applied** VDATUM GPS Tide

Zone file

Lines merged ☑

Data cleaned to remove gross fliers ☑

Compute correctors in this order

1. Precise Timing **2. Pitch bias** **3. Roll bias** **4. Heading bias**

Do not enter/apply correctors until all evaluations are complete and analyzed.

PATCH TEST RESULTS/CORRECTORS

Evaluators	Latency Lines Used	**Latency (sec)**	Pitch Lines Used	**Pitch (deg)**	Roll Lines Used	**Roll (deg)**	Yaw Lines Used	**Yaw (deg)**
JTH		0.0000	003, 004	0.1000	005, 007	0.1500	005, 007, 002	-0.6300
KB		0.0000	003, 004	0.1000	005, 007	0.1000	005, 007, 002	-0.3000
EC		0.0000	003, 004	0.1000	005, 007	0.2100	005, 007, 002	0.2700
CA		0.0000	003, 004	0.1200	005, 007	0.0360	005, 007, 002	-0.4800
JTH						0.1100		

	Latency (sec)	Pitch (deg)	Roll (deg)	Yaw (deg)
Averages	0.00	0.11	0.23	-0.29
Standard Deviation	0.00	0.01	0.07	0.39
FINAL VALUES	0.00	0.11	0.23	-0.29

Final Values based on

Resulting HVF File Name

MRU Align StdDev gyro	0.39	Value from standard deviation of Heading offset values
MRU Align StdDev Roll/Pitch	0.04	Value from averaged standard deviations of pitch and roll offset values

NARRATIVE

☑ **HVF Hydrographic Vessel File created or updated with current offsets**

Name: 2904_2019_KongsbergEM2040

Date: 7/16/2019

THOMAS JEFFERSON

Multibeam Echosounder Calibration Vessel: 2903 EM2040

Date Acquired: 07/15/2019

Processing Log

Date	Dn	Personnel
9/26/2019	269	CHST Hiteshew

☑ **Data converted --> HDCS_Data in CARIS**

☑ **Delayed Heave applied**

☑ **SVP applied**

☑ **SBET applied**

☑ **GPS Tide applied** VDATUM GPS Tide

Zone file

Lines merged ☑

Data cleaned to remove gross fliers ☑

Compute correctors in this order

1. Precise Timing **2. Pitch bias** **3. Roll bias** **4. Heading bias**

Do not enter/apply correctors until all evaluations are complete and analyzed.

PATCH TEST RESULTS/CORRECTORS

Evaluators	Latency Lines Used	**Latency (sec)**	Pitch Lines Used	**Pitch (deg)**	Roll Lines Used	**Roll (deg)**	Yaw Lines Used	**Yaw (deg)**
JTH	0000, 0001	0.0000	0002, 0003	-0.6000	0007, 0009	0.0400	0007, 0012	0.8900
EKC	0000, 0001	0.0000	0002, 0003	-0.4900	0007, 0009	0.0700	0007, 0012	0.7900
CBA	0000, 0001	0.0000	0002, 0003	-0.6700	0007, 0009	0.0400	0007, 0012	0.9000
KB	0000, 0001	0.0000	0002, 0003	-0.6000	0007, 0009	-0.5000	0007, 0012	0.8200
TK	0000, 0001	0.0000	0002, 0003	-0.7700	0007, 0009	0.2000	0007, 0012	1.0100
PF	0000, 0001	0.0000	0002, 0003	-0.4900	0007, 0009	0.0000	0007, 0012	0.8700
JTH						0.0700		

	Latency (sec)	Pitch (deg)	Roll (deg)	Yaw (deg)
Averages	0.00	-0.60	0.05	0.88
Standard Deviation	0.00	0.10	0.22	0.09
FINAL VALUES	0.00	-0.60	0.05	0.88

Final Values based on

Resulting HVF File Name

MRU Align StdDev gyro 0.09 Value from standard deviation of Heading offset values

MRU Align StdDev Roll/Pitch 0.16 Value from averaged standard deviations of pitch and roll offset values

NARRATIVE

☑ **HVF Hydrographic Vessel File created or updated with current offsets**

Name: 2903_2019_KongsbergEM2040 **Date:** 9/26/2019

THOMAS JEFFERSON

Multibeam Echosounder Calibration Vessel: 2903 EM2040

Date Acquired: 11/12/2019

Processing Log

11/13/2019	316	CHST Hiteshew
Date	Dn	Personnel
43781	316	Cziraki/Hiteshew

☑ **Data converted --> HDCS_Data in CARIS**

☑ **Delayed Heave applied**

☑ **SVP applied**

☑ **SBET applied**

☐ **GPS Tide applied** VDATUM GPS Tide

Zone file

Lines merged ☑

Data cleaned to remove gross fliers ☑

Compute correctors in this order

1. Precise Timing **2. Pitch bias** **3. Roll bias** **4. Heading bias**

Do not enter/apply correctors until all evaluations are complete and analyzed.

PATCH TEST RESULTS/CORRECTORS

Evaluators	Latency Lines Used	**Latency (sec)**	Pitch Lines Used	**Pitch (deg)**	Roll Lines Used	**Roll (deg)**	Yaw Lines Used	**Yaw (deg)**
JTH	0082, 0088	0.0000	0084, 0090, 0092, 0	-0.4500	0084, 0090, 0092, 0	-0.9400	0084, 0086	-0.4700
				-0.8600		-0.9700		-0.4800
EKC		0.0000		-0.5400		-0.9600		-0.4000

Averages	0.00	-0.62	-0.96	-0.45
Standard Deviation	0.00	0.22	0.02	0.04
FINAL VALUES	0.00	-0.62	-0.96	-0.45

Final Values based on

Resulting HVF File Name

MRU Align StdDev gyro 0.04 Value from standard deviation of Heading offset values

MRU Align StdDev Roll/Pitch 0.12 Value from averaged standard deviations of pitch and roll offset values

NARRATIVE

☑ **HVF Hydrographic Vessel File created or updated with current offsets**

Name: 2903_2019_KongsbergEM2040 **Date:** 11/13/2019

THOMAS JEFFERSON

Multibeam Echosounder Calibration Vessel: 2904 EM2040

Date Acquired: 12/05/2019

Processing Log

Date	Dn	Personnel
12/5/2019	339	CHST Hiteshew

☑ **Data converted --> HDCS_Data in CARIS**

☑ **Delayed Heave applied**

☑ **SVP applied**

☑ **SBET applied**

☑ **GPS Tide applied** VDATUM GPS Tide

Zone file

Lines merged ☑

Data cleaned to remove gross fliers ☑

Compute correctors in this order

1. Precise Timing **2. Pitch bias** **3. Roll bias** **4. Heading bias**

Do not enter/apply correctors until all evaluations are complete and analyzed.

PATCH TEST RESULTS/CORRECTORS

Evaluators	Latency Lines Used	**Latency (sec)**	Pitch Lines Used	**Pitch (deg)**	Roll Lines Used	**Roll (deg)**	Yaw Lines Used	**Yaw (deg)**
JTH		0.0000	0006, 0007	0.8900	0006, 0007	0.1800	0006, 0011	4.4800
CA		0.0000	0006, 0007	1.1900	0006, 0007	0.1000	0006, 0011	4.5500
PF		0.0000	0006, 0007	1.0800	0006, 0007	-0.0700	0006, 0011	4.4800
CD		0.0000	0006, 0007	0.2900	0006, 0007	0.1700	0006, 0011	4.9400
						0.1000		-0.2500

	Latency (sec)	Pitch (deg)	Roll (deg)	Yaw (deg)
Averages	0.00	0.86	0.20	4.36
Standard Deviation	0.00	0.40	0.12	0.22
FINAL VALUES	0.00	0.86	0.20	4.36

Final Values based on

Resulting HVF File Name

MRU Align StdDev gyro 0.22 Value from standard deviation of Heading offset values

MRU Align StdDev Roll/Pitch 0.26 Value from averaged standard deviations of pitch and roll offset values

NARRATIVE

☑ **HVF Hydrographic Vessel File created or updated with current offsets**

Name: 2904_2019_KongsbergEM2040 **Date:** 12/19/2019

THOMAS JEFFERSON

Multibeam Echosounder Calibration Vessel: 2904 EM2040

Date Acquired: 12/18/2019

Processing Log

12/19/2019	352	CHST Hiteshew
Date	Dn	Personnel

☑ **Data converted --> HDCS_Data in CARIS**

☑ **Delayed Heave applied** ____________________

☑ **SVP applied** ____________________

☑ **SBET applied** ____________________

☑ **GPS Tide applied** VDATUM GPS Tide

Zone file ____________________

Lines merged ☑

Data cleaned to remove gross fliers ☑

Compute correctors in this order

1. Precise Timing **2. Pitch bias** **3. Roll bias** **4. Heading bias**

Do not enter/apply correctors until all evaluations are complete and analyzed.

PATCH TEST RESULTS/CORRECTORS

Evaluators	Latency Lines Used	**Latency (sec)**	Pitch Lines Used	**Pitch (deg)**	Roll Lines Used	**Roll (deg)**	Yaw Lines Used	**Yaw (deg)**
JTH		0.0000	0043, 0044	-0.6500	0043, 0044	-0.0300	0041, 0046	1.7300
EC		0.0000	0043, 0044	-0.8000	0043, 0044	0.1000	0041, 0044	2.0400
CD		0.0000	0043, 0044	-0.7300	0043, 0044	0.1400	0041, 0046	1.8900
PF		0.0000	0043, 0044	-0.3900	0043, 0044	0.0800	0041, 0046	1.7600
CA		0.0000	0043, 0044	-0.5000	0043, 0044	0.1000	0041, 0046	1.7000
						0.5500		-0.2000

Averages	0.00	-0.61	0.63	1.62
Standard Deviation	0.00	0.17	0.06	0.14
FINAL VALUES	0.00	-0.61	0.63	1.62

Final Values based on ____________________

Resulting HVF File Name ____________________

MRU Align StdDev gyro	0.14	Value from standard deviation of Heading offset values
MRU Align StdDev Roll/Pitch	0.12	Value from averaged standard deviations of pitch and roll offset values

NARRATIVE

☑ **HVF Hydrographic Vessel File created or updated with current offsets**

Name: 2904_2019_KongsbergEM2040 **Date:** 12/19/2019